GREEN AND BLUE ECONOMY ON THE THRESHOLD OF DIGITAL CHANGE

Textbook

Edited by

Irina Tatomyr

Drohobych State Pedagogical University after Ivan Franko (Ukraine)

Liubov Kvasnii

Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management (Ukraine)

eBook **ISBN 978-80-88415-36-7**

Print **ISBN 978-80-88415-37-4**

OKTAN PRINT
PRAHA 2021

Recommended for publication by the Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management (Protocol №2 dated 17.09.2021)

The work was performed within the research topic of the Mykhailo Hrushevsky Precarpathian Institute «Ukraine in the context of world and national modernization processes of statehood and civil society: political, legal, economic, social, psychological and administrative aspects» (Registration number 0119U100492. Date of registration - February 12, 2019)

Reviewers:

Levan Jakeli Professor, Dean of the Faculty of Law of Batumi State University. Sh. Rustaveli (Georgia)

Justyna Krzywkowska Doctor of Law, assistant professor Department of Legal Theory and History Faculty of Law and Administration University of Warmia and Mazury in Olsztyn (Poland)

Yeliseyeva Oksana Doctor of Economics, Professor, Head of the Department of Statistics, Accounting and Economic Informatics of Dnipro National University named after Oles Honchar (Ukraine)

Editors:
Irina Tatomyr PhD in Economics, Associate Professor
Liubov Kvasnii Ph.D in Economics, Associate Professor

GREEN AND BLUE ECONOMY ON THE THRESHOLD OF DIGITAL CHANGE: *textbook*; Edited by I. Tatomyr, L. Kvasnii. Praha: OKTAN PRINT, 2021, 324 p.

The publication is assigned with a DOI number: **https://doi.org/10.46489/gabeott-10**

The paper version of the publication is the original version. The publication is available in electronic version on the website: **https://www.oktanprint.cz/p/green-and-blue-economy**

Passed for printing 27.09.2021
Circulation 50 copies
Cover design: *Irina Tatomyr*

eBook **ISBN 978-80-88415-36-7**

Print **ISBN 978-80-88415-37-4**

OKTAN PRINT s.r.o.
5. května 1323/9, Praha 4, 140 00
www.oktanprint.cz
tel.: +420 770 626 166
jako svou 78. publikací
Výdání první

Contents

……………………

I. PRINCIPLES OF DEVELOPMENT OF MODELS OF «BLUE» AND «GREEN» ECONOMIES

1.1 Prerequisites for the development of the green economy model and its basic postulates

Yulia Orlovska
Doctor of Sciences (Economics),
Professor of Department of International Economics
and Public Administration
Prydniprovska State Academy of Civil Engineering and Architecture
E-mail: juliaorlovska@pgasa.dp.ua
ORCID ID 0000-0002-5915-4261

Veronika Chala
Ph.D. in Economics,
Associate professor of Department of International Economics
and Public Administration
Prydniprovska State Academy of Civil Engineering and Architecture
E-mail: chala.veronika@pgasa.dp.ua
ORCID ID 0000-0002-2233-2335

Kristina Dryhola
Ph.D. student in Economics,
Assistant of Department of International Economics
and Public Administration
Prydniprovska State Academy of Civil Engineering and Architecture
E-mail: drygola.kristina@pgasa.dp.ua
ORCID ID 0000-0001-7928-6408

Today, the economic system is undergoing a global transformation – from resource-dependent linear to resource-efficient circular type. The trigger for the transition was the adoption of the concept of sustainable development in the late 1980s, which strengthened the emphasis on a type of economic growth that would take into account the interests of future generations and not limit their ability to meet their needs.

The following decades were characterized by the gradual «greening» of the economy, which was accompanied by the emergence of new theories of economic development. The culmination of this process was the emergence of a new type of economic system – the *green economy*, which is closely intertwined with the concept of sustainable development, circular economy and bioeconomy, but these are not identical concepts. That is why the historical preconditions for the emergence of a green economy are in the field of development of ideas about sustainable development and are at the intersection of ecological and environmental economics.

Chronologically, it is possible to divide the period of green economy development into several stages: *preparatory* (shifting the focus of research to the intersection of environmental and economic spheres), *formative* (emergence of the concept of «green economy» and its separation into an independent direction of research), *active development* (the emergence of a common definition of the green economy, the formation of the theoretical basis of the concept and areas of practical implementation and evaluation), *modern* (strategies for the development of the green economy in the context of global transformations and challenges) (Table 1).

Table 1

Chronology of development of the «green economy» concept

The name of the stage	Period	Key events
Preparatory	1962	Publication of R. Carson's book «Silent Spring» [1], which was the impetus for the development of economic research in terms of ecology
	1960-1970	The emergence and development of theories of balanced development: N. Georgescu-Roegen (law of entropy) [2; 3], K. Boulding («Economics of the Coming Spaceship Earth», the theory of equilibrium of matter) [4]
	1972	United Nations Conference on the Human Environment, Stockholm, at which the Stockholm Declaration was signed, consisting of 26 principles of environmental protection [5]
	1970-1980	Development of theories of rational development: A. Markandia, D. Pierce (monetary assessment of environmental policy), A. Ness (the concept of «ecosophy») [6]
	1983	Establishment of the World Commission on Environment and Development (Brundtland Commission)
	1987	Report of the Brundtland Commission «Our Common Future», which for the first time provides a definition of the concept of sustainable development [7]
	1989	Report of the Government of the United Kingdom «Blueprint for a Green Economy» (D. Pierce, E. Barbier, A. Markandia) [8], which explains the concept of sustainable development. The concept of «green economy» is used only in the title of the report
Formative	1991	«Blueprint 2: Greening the World Economy» (D. Pierce, E. Barbier, A. Markandia). The distinction between the concepts of green economy and sustainable development has begun with the publication of this report [9]
	1992	The United Nations Conference on Environment and Development (Rio de Janeiro) adopted the Agenda 21 [10], the Declaration on Environmental Protection and the Convention on Climate Change, Biodiversity and the Principles of Forest Protection
	1993	«Blueprint 3: Measuring Sustainable Development» (D. Pierce) [11], which provided a deeper assessment of economic development, taking into account the environmental component
	1997	Rio + 5 [12], which summed up the first results of the implementation of the «Agenda 21» and noted the lag behind the planned indicators
	2000	United Nations Millennium Summit, which required sustainable development by 2015
	2008	UNEP Green Economy Initiative [13]
	2008	Creation of the Green European Foundation (GEF) - a political fund of the European level [14]
Active developme	2009	UNEP Global Green New Deal (GGND), E. Barbier [15]
	2009	United Nations Climate Change Conference in Copenhagen, which publishes a statement in support of the green economy

	2010	UNEP Global Environment Ministers' Forum in Nusa Dua, Indonesia, recognizing UNEP's leading role in the green economy
	2011	UNEP Green Economy Report, which for the first time provides a definition of the green economy as a type of system that increases the standard of living and well-being of people, as well as social justice, while reducing environmental risks and resource dependence of economic processes. It is low-carbon, resource-saving and socially inclusive [16]
	2012	United Nations Conference on Sustainable Development Rio + 20, one of the topics of which was the development of a green economy, supported by Resolution 64/236 [17]
	2012	Establishment of the Global Green Growth Institute (GGGI) [18]
Modern	2012	Establishment of the Global Green Knowledge Platform (GGKP) [19] with the support of the Global Institute for Green Growth, the Organization for Economic Cooperation and Development, the United Nations Environment Program, the United Nations Industrial Development Organization, and the World Bank.
	2015 p.	Summit on Sustainable Development in New York, which presented the global goals of sustainable development to be achieved by 2030 («17 goals of sustainable development»)
	2019 p.	Development strategy until 2030 «Low-carbon, sustainable world of strong, inclusive and sustainable development» under the auspices of the Global Institute for Green Growth [20]
	2020 p.	Congress of the Green Economy, which addressed the development of the concept and its implementation at all levels of the EU [21]

Source: developed by the authors based on [1-21]

Summarizing the chronology of development of the concept of green economy, it is possible to note the existence of interdependent concepts – *green economy*, *green growth* and *sustainable development*. Green growth is characterized as a type of economic growth that is formed on the basis of green investment and strengthening the green sector of the economy and the creation of new green jobs in terms of social inclusion. In turn, green growth ensures the formation of a green economy – an economic system that ensures the sustainability of the environment through the greening of business and is a condition for achieving global goals of sustainable development. That is, green growth is a type of economic development in which a green economy is achieved as an economic system within the framework of which it becomes possible to achieve global goals of sustainable development.

According to Prushkivska E. and Shevchenko Y. [22], these three concepts can be considered in a comparative analysis of three aspects: economic, environmental and social. In the *economic aspect*, green growth is the basis of economic progress through green innovation, technology, jobs, which takes into account the state of the environment, and not just achieved through GDP growth. The green economy, in turn, contributes to the attraction of green investment at the public and private levels and forms the flexibility of the economic system through new types of economic activity. Sustainable development involves reducing investment in those areas of economic activity that are environmentally harmful, as well as limiting production and consumption in economically developed countries with the simultaneous support of developing countries.

In the *social aspect*, green growth ensures the well-being of the population through the goods and services of the «green» sector and creates new «green» jobs in terms of social inclusion. The green economy creates the conditions for achieving a high standard of living and ensuring fundamental human rights and freedom in terms of gender equality and inclusion. Sustainable development involves the equalization of economic prosperity and social justice among all members of society while increasing the level of human capital.

In the *environmental aspect*, green growth is aimed at developing the green sector of the economy, through green investment, innovation, support for environmentally friendly areas of activity, which in the long run ensures minimization of environmental pollution and climate and environmental sustainability. The green economy focuses on leveling the negative impact of human economic activity by strengthening the responsibility of each business entity and reducing the burden on the environment. Sustainable development ensures the stability of the environment and the continuous improvement of the efficiency of the use of available resources and the reduction of the negative impact on the environment.

If we consider the relationship between these concepts more broadly, we can see that one concept is the result of another, and the original concept is green growth. It, in turn, is provided by «green policies» of states within the framework of the Global Green New Deal (GGND) [23; 24]. In addition, the green economy directly affects the achievement of the global goals of sustainable development, namely (according to UNEP documents [25]) the following goals: 1 (poverty reduction), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 11 (sustainable development of cities and communities), 12 (responsible consumption and production).

Considering these components as one functional system (Fig. 1), it is possible to give each its role. Thus, the initial condition of the system (*input*) can be considered a «green» policy of states within the Global Green New Deal, which creates the necessary regulatory framework for green growth through financial and administrative methods. Under these conditions, it becomes possible to move to green growth, which is to strengthen the green sectors of the economy and acts as a driving force of the system (*driving force*).

According to the classification of the EU Green Policy Platform [26], there are 13 green sectors: agriculture, green building, alternative energy, green finance, fisheries, forestry, information technology, green production, metals and minerals, green tourism, green transport, waste management, water resources management. At the same time, green growth is formed on the basis of the achievements of the circular economy, bioeconomy, innovation and intellectual economy.

Circular economy, or closed-cycle economy, is based on the rational consumption of resources and the formation of a closed cycle of their use, in contrast to the linear type of economy. The basis of this process is the recycling of raw materials, the transition to renewable energy sources and, as a result, the reduction of negative impact on the environment.

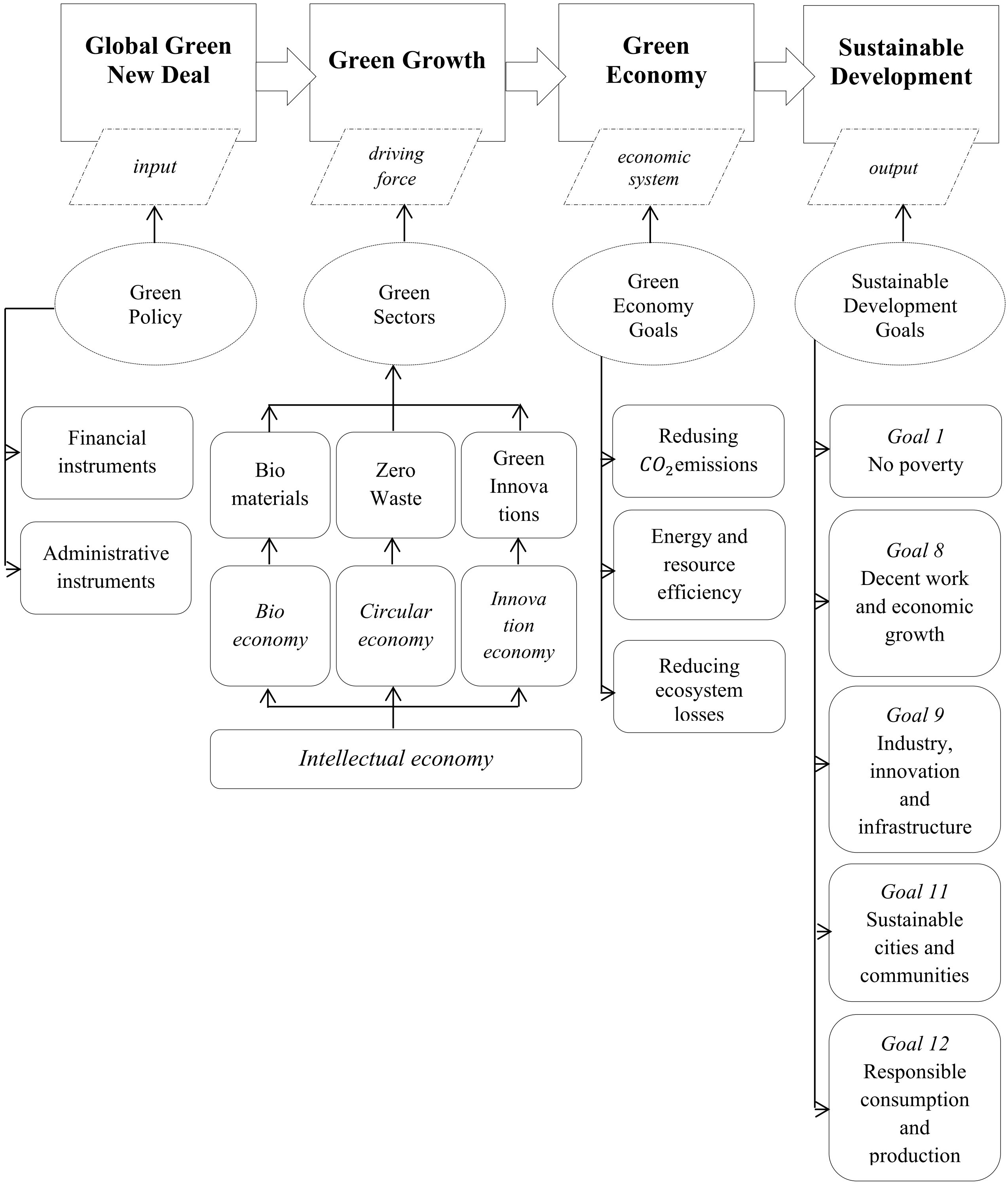


Fig. 1. Functional system of green economy and its impact on sustainable development goals

Source: developed by the authors

The postulates of the circular economy, in turn, have led to the concept of «zero waste», which not only aims to close the cycle, but transforms the cycles of resource consumption in such a way as to minimize the recycling of resources by creating products and services, which are consumed in full, leaving no waste. This concept should be the basis of strategies for rational waste management and be the foundation of ecological production within the green economy.

Directly closed-loop production processes should be formed on the basis of the use of green biotechnologies, which are the main postulates of bioeconomics, which is a type of economic development in which there is a transition to the use of biological materials in production cycles and abandonment of synthetic, toxic, harmful substances, as well as fossil fuels and non-renewable resources with their replacement by natural substances and materials, alternative energy sources, innovative green technologies and business models.

The postulates of the circular and bioeconomy are the basis for the creation and implementation of green innovations, which are the foundation of green growth and should be stimulated primarily in the «green» sectors of the economy. Green innovations are formed within the innovation economy, which is based on a continuous flow of innovation, technical modernization, research and development.

The key catalysts for green growth are 5 types of capital [27]: natural (ecosystems, natural resources); human (labor, education, health), social (inclusion, culture, social infrastructure), industrial (industry, physical infrastructure), financial (investment, financial institutions and incentives). All types of capital must be used effectively to achieve results in three aspects: economic, social and environmental. It is the efficiency of capital combination that is determined by the high level of qualification of green sector specialists, which reflects the high level of development of intellectual resources. That is why the foundation of the transformation and development of the green sector is the intellectual economy within which intellectual resources are formed, which are the driving force of the entire functional system of the green economy.

The result of green growth through the development and support of the green sectors is the achievement of a new type of *economic system* «green economy», which is characterized by a high level of economic and social development and simultaneous environmental sustainability, which is expressed in achieving green economy goals. According to UNEP [27], the main goals of the green economy include: reduction of carbon emissions and environmental pollution; increase of energy and resource efficiency; leveling the loss of biodiversity and negative impact on ecosystems. The implementation of goals should be based on the basic *principles* [45] of the green economy (Fig. 2).

1. *The principle of well-being.* The green economy is human-centered, and aims to achieve public welfare – economic, social, spiritual through access to basic goods, social inclusion, high level of education, the creation of decent jobs. Thus the green economy can be considered intellectually oriented. That is why it is intertwined with the concept of intellectual economy. Achieving the goals of a green economy is possible only with the intellectualization and greening of human activity.

2. *The principle of justice*. The green economy is inclusive, non-discriminatory and based on gender equality. This allows to increase the efficiency of human potential and, accordingly, increases the level of economic development.

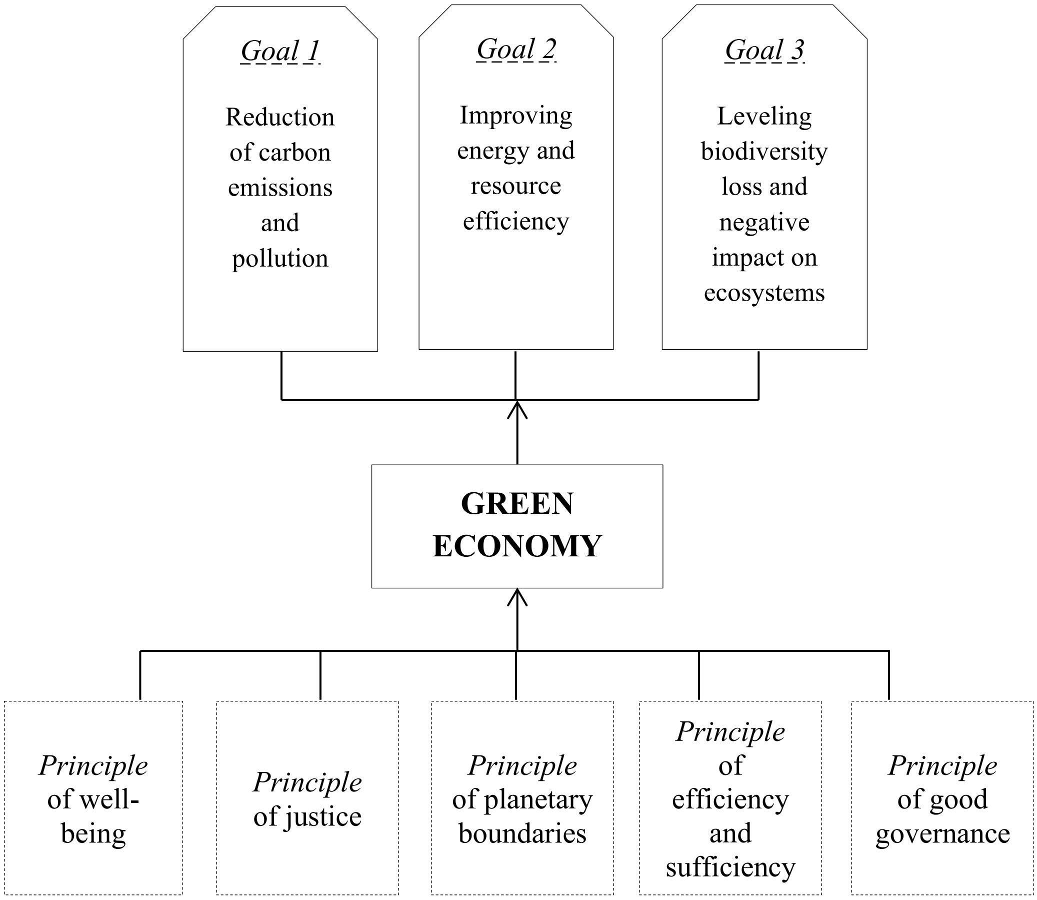


Fig. 2 Fundamental principles and goals of the green economy
Source: developed by the authors based on [27]

3. *The principle of planetary boundaries*. The green economy recognizes the limited substitutability of natural capital and invests in maintaining the sustainability of ecosystems and biodiversity on a global scale.

4. *The principle of efficiency and sufficiency*. The green economy is aimed at sustainable production and conscious consumption based on the establishment of a social minimum and maximum with an effective response to externalities. Thus, economic entities that carry out environmentally harmful activities should financially compensate for the damage caused, and those entities that carry out environmentally oriented activities should receive financial incentives.

5. *The principle of good governance*. The green economy should be guided by institutions that take responsibility for the state and functioning of all types of capital and are guided by environmentally oriented principles in their activities. These principles should be implemented through the creation of an appropriate «green» regulatory field, which should determine the activities of all economic entities.

Under the conditions of the green economy it becomes possible to achieve global goals of sustainable development, which is the initial result of the system (*output*) with emphasis on goals 1, 8, 9, 11 and 12. Thus, analyzing all elements of the green economy in a single functional system, it becomes clear to connect each element and its functions. The green economy is often considered in connection with the brown and blue economy [28]. The *brown economy* is a type of system in which development depends on environmentally destructive activities, and production cycles are based on non-renewable resources, mainly on fossil fuels: coal, peat, oil. The main manifestation of the negative impact of this type of economic system is air pollution due to emissions of carbon dioxide and methane, as well as pollution of water resources, which ultimately leads to degradation of the ecosystem.

In this context, the green and blue economy is a transformation of the brown, namely the *blue economy* – focuses on maintaining the sustainability of water resources and coastal areas and identifies them crucial for the development of society. The *green economy*, in turn, should help reduce poverty and boost economic growth, which is environmentally friendly and focuses on developing the green sectors of the economy, as well as reducing carbon emissions. This transformation can be represented in the form of a matrix of green economy (Fig. 3). The axes reflect the growth of labor productivity and green growth, depending on the degree of development of which four types of economic development are formed:

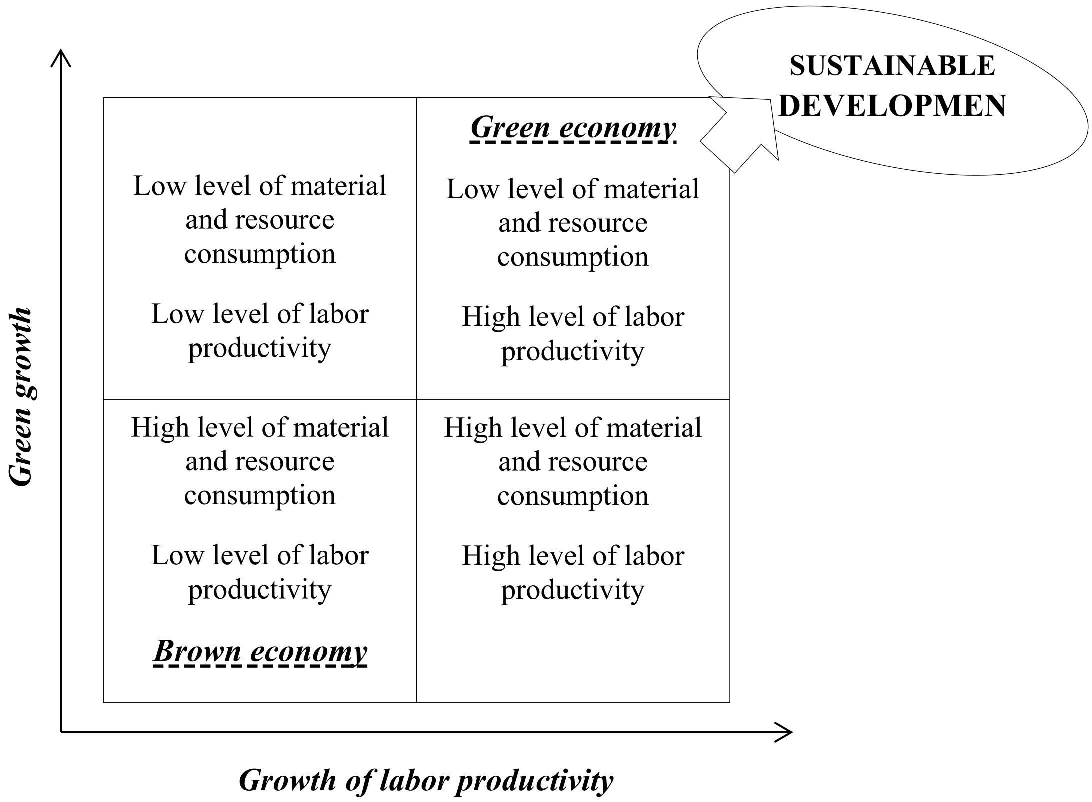


Fig. 3 Green economy matrix
Source: developed by the authors based on [27]

1) Brown economy – a low level of labor productivity and a high level of material and resource consumption.

2) Transitional type (1) – low level of labor productivity and low level of material and resource consumption.

3) Transitional type (2) – a high level of labor productivity and a high level of material and resource consumption.

4) Green economy – a high level of labor productivity and a low level of material and resource consumption.

Thus, the development of a green economy largely depends on a high level of human capital and innovation and high-tech production processes. The level of technological development depends on the scientific and technological progress of mankind, which is characterized by technological paradigm. Historically there are 6 technological paradigms (1 – textile equipment; 2 – steam engine; 3 – electric engine; 4 – internal combustion engine, petrochemistry; 5 – microelectronics; 6 – biotechnology) [29-32]. Green innovations are based on the use of biotechnology, genetic engineering, membrane and quantum technologies, which are the basis of the sixth technological paradigm.

That is why it is possible to conclude that the green economy is a modern type of economic system based on the latest achievements of the sixth technological paradigm and in the long run contributes to increasing human well-being, increasing life expectancy, reducing material and resource consumption and increasing human capital productivity [33].

Summarizing the above, it becomes possible to form a definition of a green economy. Currently, the definition of UNEP remains the main one and is cited in most scientific papers, but various scientists offer their approaches to the essence of the green economy. In our opinion, analyzing the existing theories of scientists, they can be distinguished in the following approaches (Fig. 4):

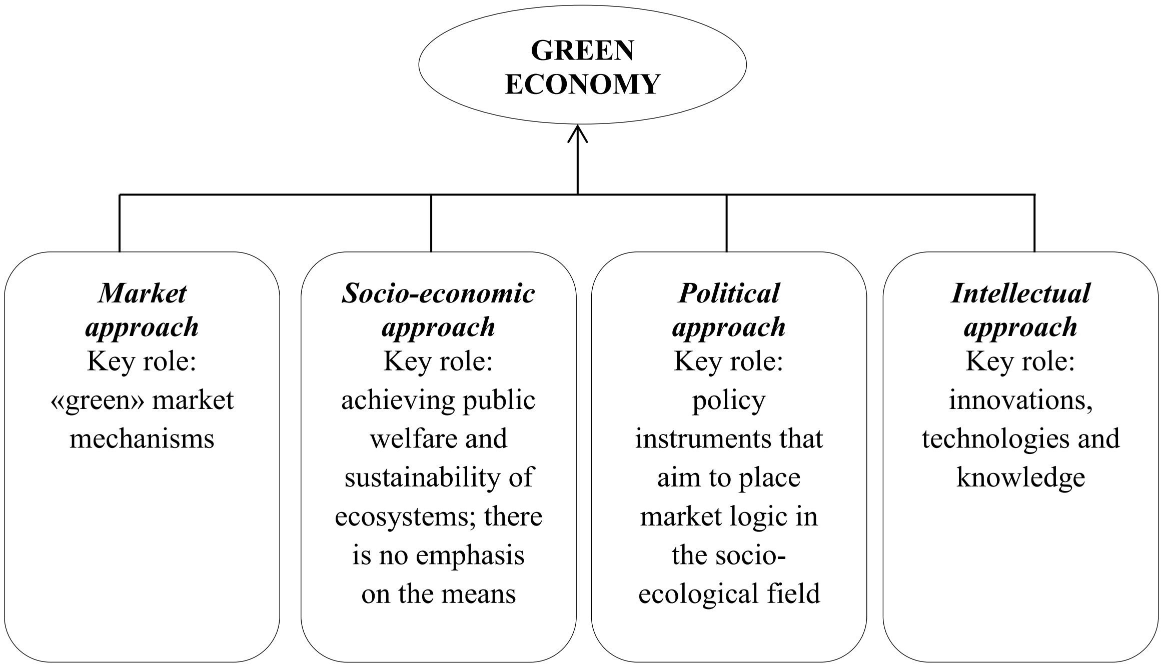


Fig. 4. Approaches to defining key elements of the green economy
Source: developed by the authors

- market – green economy is considered a type of economic system, which is achieved through «green» market mechanisms that must be implemented at all stages of production processes and ensure the balance of economic, environmental and social components;
- socio-economic – in this approach the main emphasis is shifted to the goals of the green economy, namely the achievement of social welfare and sustainability of ecosystems, while not emphasizing the way to achieve these goals;
- political – green economy is considered a political project, which aims to place market logic in the socio-ecological field;

- intellectual – according to this approach, the important role of innovation, technology and knowledge as a means of achieving a green economy is emphasized, thus the system itself receives an intellectual context.

Given these approaches and the genesis of the green economy, in our opinion, the **green economy** is a type of economic system based on green innovations, technologies and knowledge of the sixth technological paradigm, which must be implemented in economic processes at all levels in green growth, providing efficient use of natural capital, characterized by a low level of material and resource intensity by increasing the level of human capital development in order to achieve global goals of sustainable development. In our opinion, the intellectual component of the green economy is a key factor in its formation and development, and therefore needs a more detailed analysis of scientist. The green economy should become a new paradigm of the modern world, and its goals and principles must be the basis of development strategies of all countries.

REFERENCES

1. Carson R. (1962). Silent Spring. Boston: Houghton Mifflin, 368 p.

2. *Georgescu-Roegen N.* (September 1965), *Process in farming versus process in manufacturing: a problem of balanced development. Proceedings of the Conference of the International Economic Association* [Economic Problems in Agriculture in Industrial Societies] (Italy). London: Macmillan. P. 71-102.

3. Georgescu-Roegen N. (1977). The Steady State and Ecological Salvation: A Thermodynamic Analysis. *BioScience*, 27 (4), 266–270. **DOI:10.2307/1297702. JSTOR 1297702.**

4. Kenneth E. Boulding (1966). The Economics of the Coming Spaceship Earth. Retrieved from: https://www.laceiba.org.mx/wp-content/uploads/2017/08/Boulding-1996-The-economics-of-the-coming-spaceship-earth.pdf (Last accessed: 03.08.2021)

5. UN (5-16 June, 1972) Report of the United Nations Conference on the Human Environment (Belgium). New York: UN. Retrieved from: https://www.un.org/ga/search/view_doc.asp?symbol=A/CONF.48/14/REV.1 (Last accessed: 03.08.2021)

6. Pearce, D. W. & Markandya, Anil. & Organisation for Economic Cooperation and Development (1989). Environmental policy benefits: monetary valuation. Paris: Washington, D.C: Organisation for Economic Cooperation and Development; OECD Publications and Information Centre.

7. World Commission on Environment and Development (1987). Our common future. Oxford: Oxford University Press. Retrieved from: https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf (Last accessed: 03.08.2021)

8. Pearce, D. W., Barbier, E. and Markandya, A. (1989) Blueprint for a green economy. London: Earthscan. 192 p.

9. Pearce, D. W., Barbier, E. and Markandya, A. (1991). Blueprint 2: Greening the World Economy. Lomdon: Earthscan. 232 p.

10. *UN* (3-14 June, 1992) *United Nations Conference on Environment & Development* (Brazil). Retrieved from: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf (Last accessed: 03.08.2021)

11. Pearce, D. W. (1993) Blueprint 3: measuring sustainable development. London: Earthscan. 224 p.

12. UN (27 June 1997). Official Records of the 10th plenary meeting of the General Assembly, Nineteenth Special Session (USA). Retrieved from: https://documents-dds-ny.un.org/doc/UNDOC/GEN/N97/857/86/IMG/N9785786.pdf?OpenElement (Last accessed: 03.08.2021)

13. IISD (2008) UNEP Launches Green Economy Initiative. Retrieved from: http://sdg.iisd.org/news/unep-launches-green-economy-initiative/ (Last accessed: 03.08.2021)

14.GEF. Green Economy Congress. Retrieved from: https://gef.eu/event/green-economy-congress/ (Last accessed: 03.08.2021)

15. UNEP (March 2009). Global Green New Deal. Policy brief. Retrieved from: https://wedocs.unep.org/bitstream/handle/20.500.11822/7903/A_Global_Green_New_Deal_Policy_Brief.pdf?sequence=3&amp%3BisAllowed= (Last accessed: 03.08.2021)

16. UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. A synthesis for Policy Makers. Retrieved from: https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf (Last accessed: 03.08.2021)

17. UN (31 March, 2010) Resolution adopted by the General Assembly. 64/236. Retrieved from: https://www.iom.int/sites/default/files/jahia/webdav/shared/shared/mainsite/policy_and_research/un/64/a-res-64-236.pdf (Last accessed: 03.08.2021)

18. GGGI. About the Global Green Growth Institute. Retrieved from: https://gggi.org/about/ (Last accessed: 03.08.2021)

19. GPP. Green Growth Knowledge Partnership. Retrieved from: https://www.greengrowthknowledge.org/about-us (Last accessed: 03.08.2021)

20. GGGI (October 2019) GGGI Strategy 2030. A Low-Carbon, Resilient World of Strong, Inclusive and Sustainable Growth. Retrieved from: https://gggi.org/site/assets/uploads/2019/12/Strategy-2030-EXTERNAL-191212_FINAL.pdf (Last accessed: 03.08.2021)

21. GEF (2020) Green Economy Congress. Retrieved from: https://gef.eu/event/green-economy-congress/ (Last accessed: 03.08.2021)

22. Prushkivs'ka E. V., Shevchenko Ju. A. (2013) Rozvytok «zelenoi' ekonomiky»: nacional'nyj aspekt [Development of «green economy»: national aspect]. *Biznesinform*, 3. Retrieved from: http://business-inform.net/pdf/2013/3_0/186_191.pdf (Last accessed: 03.08.2021)

23. Georgeson L., Maslin M., Poessinouw M. (2017) The global green economy: a review of concepts, definitions, measurement methodologies and their interactions. *Geography and Environment*, 4 (1). 1-23 pp. **DOI: 10.1002/geo2.36**

24. Brink P, Mazza L, Badura T, Kettunen M and Withana S. (2012) Nature and its role in the transition to a green economy. The Economics of Ecosystems & Biodiversity and the Institute for European Environmental Policy, Geneva and London.

25. UNEP. Why does green economy matter? Retrieved from: https://www.unep.org/explore-topics/green-economy/why-does-green-economy-matter (Last accessed: 03.08.2021)

26. GPP. Green Sectors. Retrieved from: https://www.greengrowthknowledge.org/sectors (Last accessed: 03.08.2021)

27. UN (2011) Working towards a Balanced and Inclusive Green Economy: a United Nations System-wide Perspective. Retrieved from: https://www.zaragoza.es /contenidos/medioambiente/onu/1209-eng.pdf (Last accessed: 03.08.2021)

28. Matthews R. (2013). Environmental Implications of Three Types of Economies: Brown, Blue and Green. Retrieved from: https://thegreenmarketoracle.com/2013/10/04/environmental-implications-of-three/ (Last accessed: 03.08.2021)

29. Chuhno A. (2001). Cyvilizacijnyj i formacijnyj pidhody ta i'h rol' v ekonomichnij teorii' ta suspil'nij praktyci [Civilizational and formational approaches and their role in economic theory and social practice]. *Economy of Ukraine*, 6, 39-47.

30. Kul'chyc'kyj B. V. (2003). Ekonomichni systemy suspil'stva: teorija, metodologija, typologizacija [Economic systems of society: theory, methodology, typology]. Lviv: LNU named after Ivan Franko.

31. Bocharova Ju. G. (2016) Konceptual'ni osnovy teorii' konkurentnogo rozvytku [Conceptual bases of the theory of competitive development]. *Bulletin of the Mykhailo Tuhan-Baranovsky Donetsk National University of Economics and Trade. Series: Economic Sciences*, 64, 77-84.

32. Jerohin S. (2006) Tehnologichni uklady, dynamika cyvilizacijnyh struktur ta ekonomichna perspektyva Ukrai'ny [Technological systems, dynamics of civilization structures and economic perspective of Ukraine]. *Economic Journal – XXI*, 1 (2), 34-38.

33. Orlovska Ju., Drygola K., Baltaksa D. (2020). Teoretychnyj bekgraund zelenoi' ekonomiky v ramkah svitovoi' paradygmy stalogo rozvytku [Theoretical background of the green economy within the world paradigm of sustainable development]. *Economic Scope*, 160, 23-27. **DOI: 10.32782/2224-6282/160-4**

1.2. The «blue economy» development features as a basis for «smart» use of available resources

Marta Dmytryshyn
Ph.D. (economic)
Associate professor in the Department of Management and Administration
Ivano-Frankivsk Educational and Scientific Institute of Management
West Ukrainian National University
E-mail: m.dmytrsyhyn@wunu.edu.ua
ORCID ID 0000-0002-0609-9764

Tetyana Goran
Ph.D. (history)
Senior lecturer in the Department of International Economics,
Marketing and Management
Ivano-Frankivsk Educational and Scientific Institute of Management
West Ukrainian National University
E-mail: t.goran@wunu.edu.ua
ORCID ID 0000-0002-6618-8769

With the development of technology and the emergence of new ideas, the population increase of our planet, new needs of a higher order have arisen. During the industrial revolution, production, machinery, and equipment growth came to the fore; most attention was paid to engineering development, construction, and commissioning plants or factories. Industry progress logically led to the area of production concentration expansion. The invention of such necessary for humanity electricity, telegraph and telephone, railway, antibiotics, etc. - helped improve the quality of people's lives, their comfortable living and movement; made it possible to cure previously hopeless diseases and injuries. Thus, the industry began to shape the bright future of man and determine its prospects.

Due to the spread of infections and diseases in underdeveloped societies, little attention has been paid to the possible harm to the health and life of such industries. After all, their appearance was associated with progress. Gradually, satisfying part of human needs, there were new needs of a higher order. They, in turn, provoked new scientific developments, inventions, and industrial designs. This has led to a situation where no one sees their everyday life without the Internet, laptop or smartphone; the problem of describing the road rules for electric scooters occurs; space tickets began to be actively sold, 3D printers print models of buildings and robots perform heart operations.

All these things are the progress of humanity. However, over time, as the euphoria subsided from new opportunities, piles of accumulated garbage, contamination of water bodies with hazardous waste, the emergence of new viruses and diseases (such as coronavirus infection or allergies), the detrimental effects of computer game addiction became more visible. Along with this, the population of the planet Earth grew, 2021 it reached 7.8 billion people (World population, 2021), and in 2064 it may reach 9.7 billion people (McNamara A.,2020*)*. As a result, large areas of our planet have gradually turned into a wasteland, become uninhabitable and useless for food-growing. In particular, in Ukraine, 2,569.4 km^2 belongs to the Chornobyl Exclusion Zone (Interactive map of administrative-territorial units of Ukraine). Moreover, 51 million km^2 of our planet is used for agriculture, which is only half of the habitable land (Ritchie H., 2019). As a result, in 2021, about 270 million people facing crisis levels of hunger (World could face "hunger pandemic" in 2021, World Food Programme head warns, 2020). Humankind needs resources to ensure their existence and the comfortable living of people around the world. Increasingly, the scientific community and the public began to talk about the inability of the planet to meet all these needs; calculation of the ecological footprint, i.e., the impact on the environment, have become available for use by the average person (Ecocalcultor, 2021).

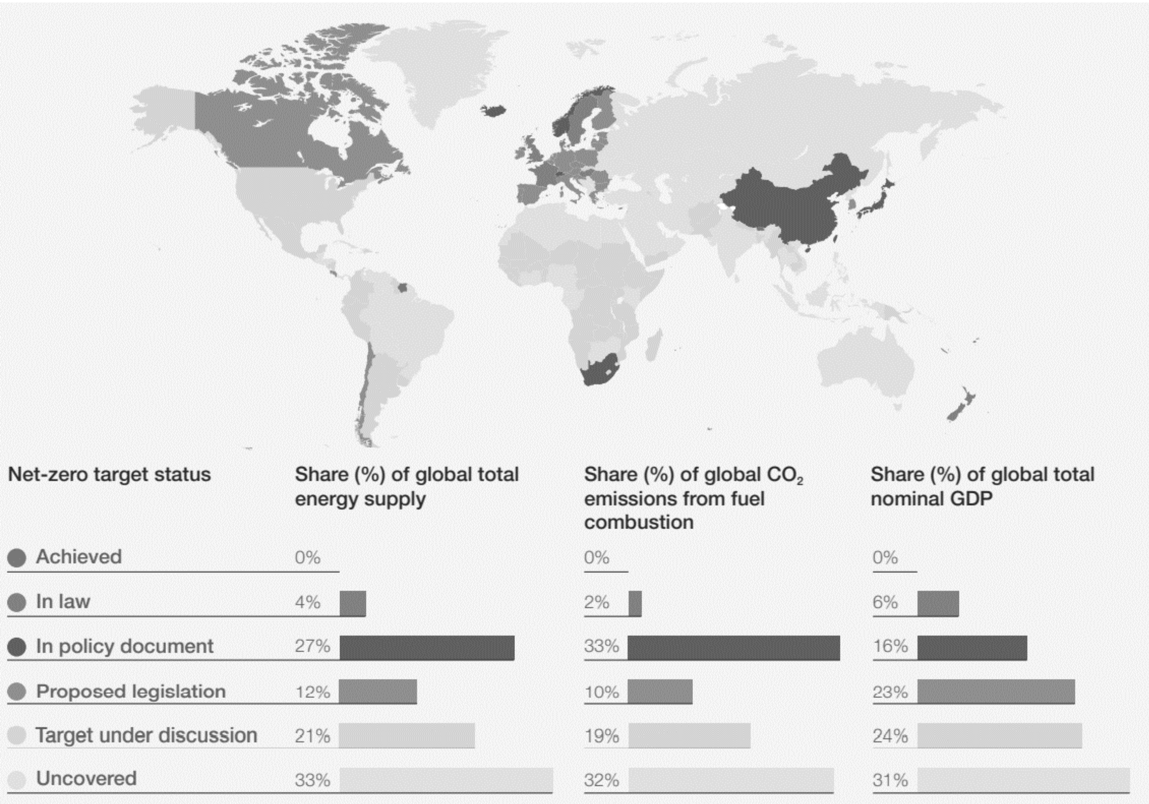


Figure 5. Status of countries' net-zero targets, 2020
Source: Fostering Effective Energy Transition 2021 edition (2021)

Many nation-states have already included emission reduction plans and programs and provided government support for energy savings. Last year saw a proliferation of net-zero announcements and targets. Around 68% of the world's emissions from fuel combustion are covered by some net-zero target (Figure 5). This compares with just 16% a year earlier. One of the most significant announcements came from China, with a mandate to achieve net-zero by 2060. However, this ratcheting up of ambition needs to be reflected in legislation, policy, and regulation and supported by concrete roadmaps and milestones (Climate Action Tracker, "Methodology Note", CAT Climate governance series, 2020).

As shown in Fig 1, there are still 1/3 of the world nations that have left net-zero targets wholly uncovered. Among them, we can see, for instance, such a big (considering the territory) country as Russian Federation (Russian export, 2020). Oil and gas are the primary export goods for this country (Top3: Crude Petroleum ($123B), Refined Petroleum ($66.2B), Petroleum Gas ($26.3B), so we can conclude that this interest is not under the agenda due to big profits and mass usage of fuel. In order to strengthen the ability to ensure quality and comfortable living for all people on our planet, there is a need for moderate production and consumption, saving limited resources and minimizing environmental damage. However, minimized damage remains damage by definition. This leads to the logical conclusion that if we treat the environment around us as consumers and overuse resources year by year, in the future, we will not have enough of the whole planet to implement our plans and desires.

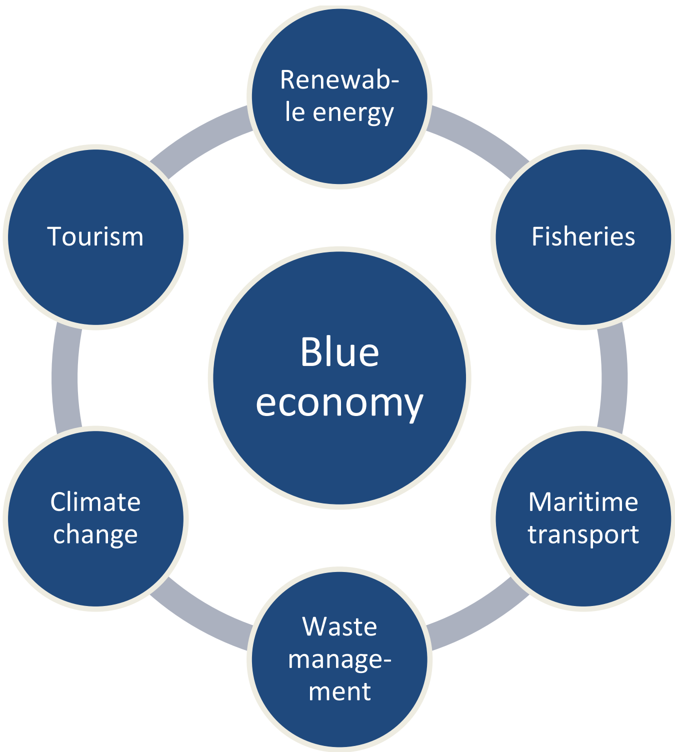


Figure 6. Activities of the Blue Economy due to the World Bank
Source: built by the authors based on What is the Blue Economy? (2017)

When the people have realized the need to save resources and minimize environmental damage, the "green economy" began to develop, but gradually this idea became insufficient for the harmonious development of the world. Thus, the concept of "green economy" was supplemented by the so-called "Blue Economy". For example, the World Bank interprets the Blue Economy as the sustainable use of ocean resources for economic growth, improving the lives and well-being of people, creating jobs while maintaining a healthy ocean ecosystem. Thus, according to this concept, the Blue Economic has many components (Figure 6).

The World Bank has its arguments for including every activity into the concept of the Blue Economy. For instance:

- sustainable marine energy plays a vital role in social and economic development;
- marine fisheries contribute more than US$270 billion annually to the global gross domestic product;
- the sea transports over 80% of international goods, and this volume is expected to double by 2030;
- 80% of the litter in the ocean is from land-based consumers;
- oceans are essential carbon sinks and help to mitigate climate change;
- oceans and coastal tourism receive more than 41 million visitors annually.

The European Green Deal and the Recovery Plan for Europe will define the European economy for many years or even decades. Furthermore, the EU's Blue Economy is fundamental to both efforts. Not only should the Blue Economy adhere, like every other sector, to the European Green Deal. It is also indispensable to meet the EU's environmental and climate objectives. After all, the ocean is the primary climate regulator we have. It offers clean energy and sustains us with oxygen, food, and many critical resources. There cannot be green without blue (A new approach for a sustainable Blue Economy in the EU, 2021).

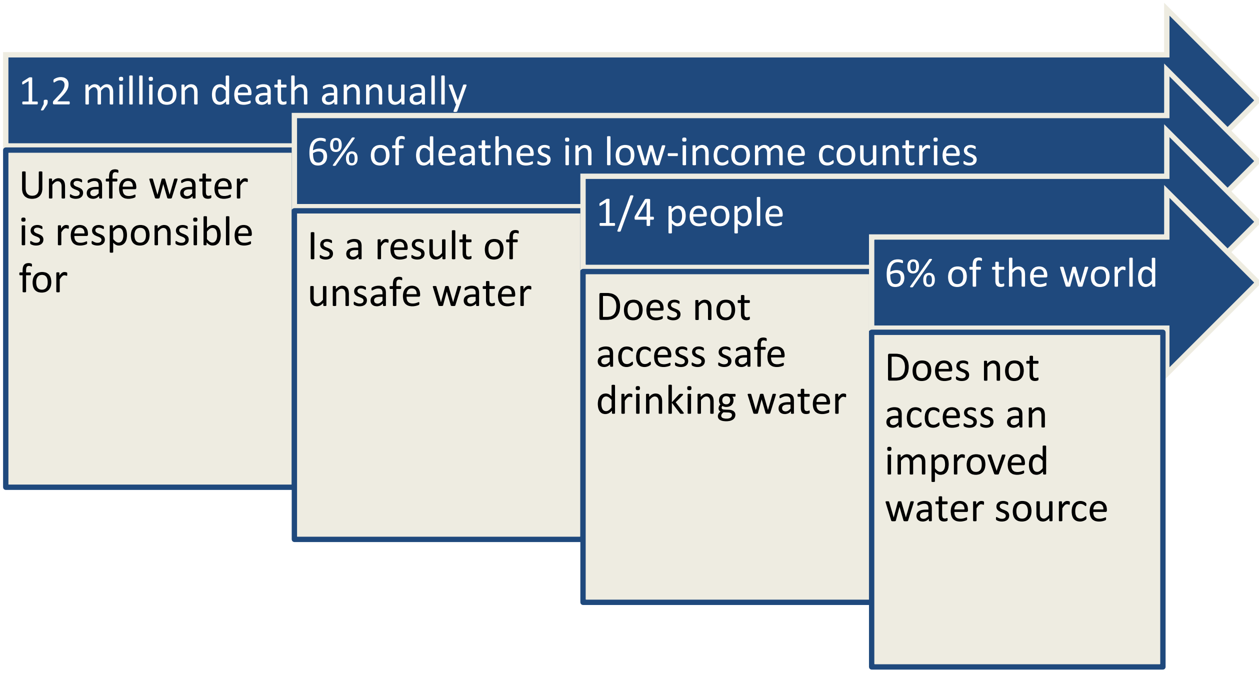


Figure 7. Clean water world summary
Source: constructed by the authors based on (Ritchie H. & M. Roser, 2019)

Along with the apparent contribution of the oceans and seas, maintaining a clean climate and creating new jobs, access to clean and safe drinking water is a critical component of the Blue Economy. Due to the recent World data statistics, this leading resource is not accessed by millions of people on our planet (Figure 7).

However, the Blue Economy concept acquired a much deeper meaning thanks to the idea of Gunter Pauli. The author of books on this topic has significantly expanded the Blue Economy's knowledge as an economy leading to an innovative view of world development in general.

If we mainly consider minimizing environmental damage through the destructive impact on human nature, then Pauli seeks a radically different approach to developing the future economy. Without denying the need for a quality life for billions of people, getting enough income for the business, the entire satisfaction of the living needs in all corners of the globe with no harm to the environment, at first glance, may seem something fabulous and incredible. Albeit, the author argues that gradually such a world can and should become a reality.

Instead of fighting waste, spending much money on its disposal, and recycling (without avoiding environmental damage), Gunter Pauli offers an innovative approach to organizing economic activities, which involves their use for good purposes. All only need to rationally consider and organize the production process based on nature and elementary physics laws. We do not make good use of the advantages and possibilities of physics, such phenomena as water, temperature, pressure, solar energy, or gravity. Production should be planned when making any item so that all waste from the main product is used for other ancillary products. After all, waste does not exist; any product is only a resource for another product.

In production decision-making, it is crucial to maximizing the use of local products, which are often freely available, and their use is cheaper. Moreover, if such a business still considers the traditions and customs of the local population, it can make the business idea more attractive, exciting and add competitive advantages.

The modern traditional economy is mainly based on the scarcity of resources and their limitations. However, in nature, all phenomena and processes are present harmoniously. There is usually no direct linear relationship between them; natural processes may take more time; however, this already contains a rational idea that provides scientific justification and research and can bring a specific beneficial effect. In nature, everything is in symbiosis and harmony. Therefore, we need to understand these processes and use them to good effect without harming the environment (Pauli, 2010).

If something fails, it is an occasion to think and find a better solution to the problem. After all, any challenges are untapped opportunities. Thus, we can identify several key ideas of Gunther Pauli in his concept of the Blue Economy (Figure 8).

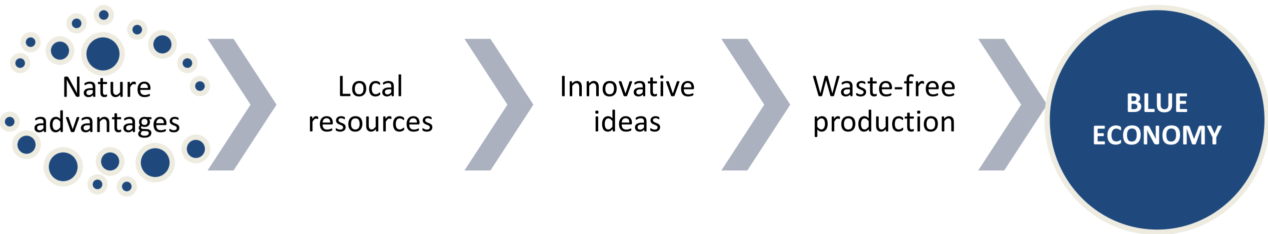


Figure 8. Key ideas of Gunter Pauli Blue Economy concept
Source: built by the authors based on Pauli (2010)

Pauli cites many examples of rational solutions to existing problems by natural methods with maximum benefit for people and the environment, supporting his ideas and conclusions. In particular, an interesting example is an experience of the

Dominican priest Godfrey Nzemunjo, who in 1985 began to implement his idea of solving the West African people's problems (Figure 9). The most severe local problems were food shortages, unsanitary conditions, and diseases. It is impressive how he managed to solve them all.

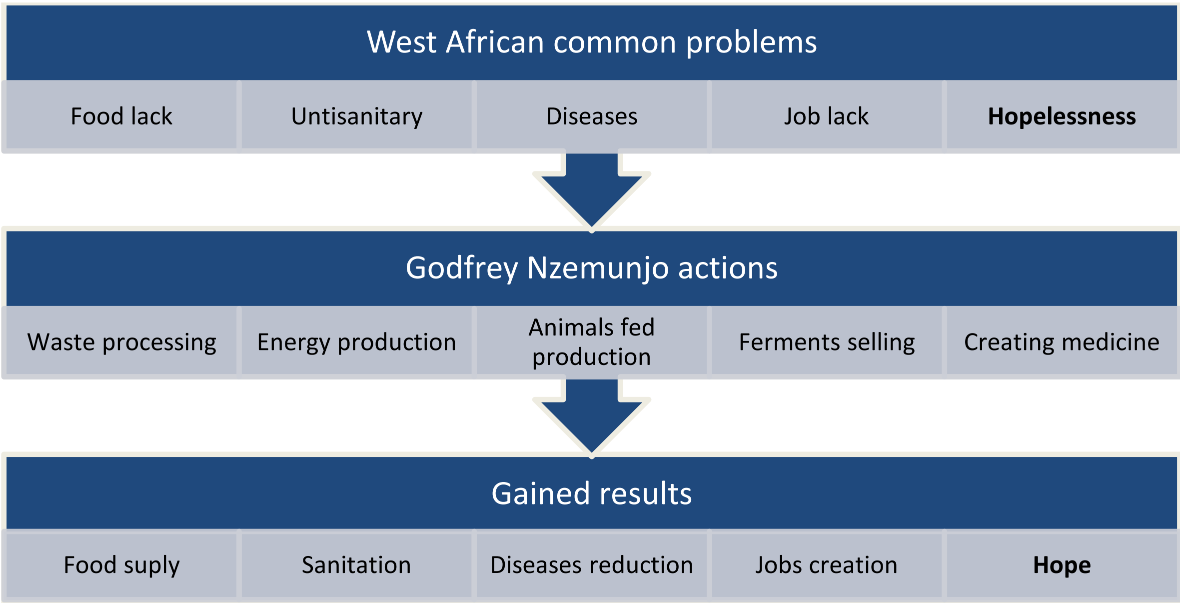


Figure 9. Model of Godfrey Nzemunjo progress
Source: developed by the authors based on Pauil (2010) & Father Godfrey Nzamujo - The Man Behind Songhai Centre (2021)

It all started with a few acres of wetlands, and a quarter of a century later, there was a complete cycle of ecological restoration of the area to provide locals with food and all the necessary means of subsistence.

Wastewater, livestock, and human waste were collected in a systematizer, where water hyacinth and a local aggressive aquatic plant were added. Thus, the systematizer provided methane, which gave energy to the economy. Moreover, its structure was designed so that the acid-base balance limited the development of dangerous bacteria. Algae bacteria, under the action of sunlight, converted carbon dioxide into oxygen. After mineralization, the material became food for plankton, which was fed to the fish.

However, Africans also had another equally severe problem - flies. These insects spread infections, caused unsanitary conditions and the development of serious diseases. For them, Nzemunjo invented a unique strategy of counteraction. All waste from local slaughterhouses was stored in a container surrounded by water-canals with carp-fish. The concave surface was covered with a net protected from birds but had sufficient loops for the fly's penetration. These wastes were unsuitable for further use, and flies were multiplied on them in a flash. This idea allowed to launch a kind of farm for the production of fly larvae with a turnover of about one ton per month. To make the larvae easy to collect on the surface, the container was simply filled with water. Larval enzymes are of great value in cosmetology and the production of ointments for wound healing. Thus, it became possible to place the larvae of flies in saltwater, collect the isolated enzyme, and sell it to large pharmaceutical and cosmetic companies. The remains of the larvae, in turn, were used to feed fish and quail, which in addition to eggs, are also a source of dietary protein meet (Father Godfrey Nzamujo - The Man Behind Songhai Centre).

Thus, the priest solved many environmental and sanitary problems of the territory, provided the local population with food, work, and income. Moreover, at the same time, it did not cause any harm to the environment. Besides this, he has also made one more crucial thing – he had given hope for locals. This example of the Blue Economy, given in Pauli's book, shows how ordinary people with the inspiration, knowledge, and desire to succeed can change the world. The Blue Economy concept encourages countries and corporations to build their economies on innovative principles. Hence, the following values come to the fore as:

1. Knowledge and education.
2. Native region's nature, problems and customs studies.
3. Support for innovation and unique ideas.
4. Belief in one's strength and ability to think "outside the box".
5. Consideration of any product as a closed waste-free harmless cycle of operations and actions.
6. Achieving profitability and business success.
7. Improving the population welfare and the quality of life (Fig. 10).

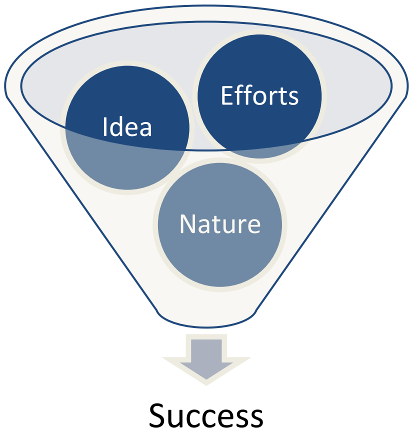


Figure 10. The representation of the success of the Blue Economy
Source: developed by the authors based on the general ideas of the Blue Economy

Along with this arises the question of how to ensure the transition to a Blue Economy. Industrial giants have mainly established stable production of their products; research and implementation of innovative ideas and technologies are risky, often require long-term implementation. However, successful projects are already operational and can be applied to working businesses (Figure 11).

In particular, G. Pauli gives an exciting example of establishing rational coffee production. This super-popular drink produces an incredible amount of waste. First, much cellulose is left over from growing coffee, which is often simply burned. Second, many coffee grounds remain during the preparation of the drink. In the end, only 0.2% of this product from the volume of coffee coming from the farm enters the human body. However, not everything is hopeless because coffee waste can be effectively used to grow popular mushrooms on the coffee substrate. Moreover, coffee material does not require additional sterilization so that the adjacent production process will be cheaper (Pauli, 2010).

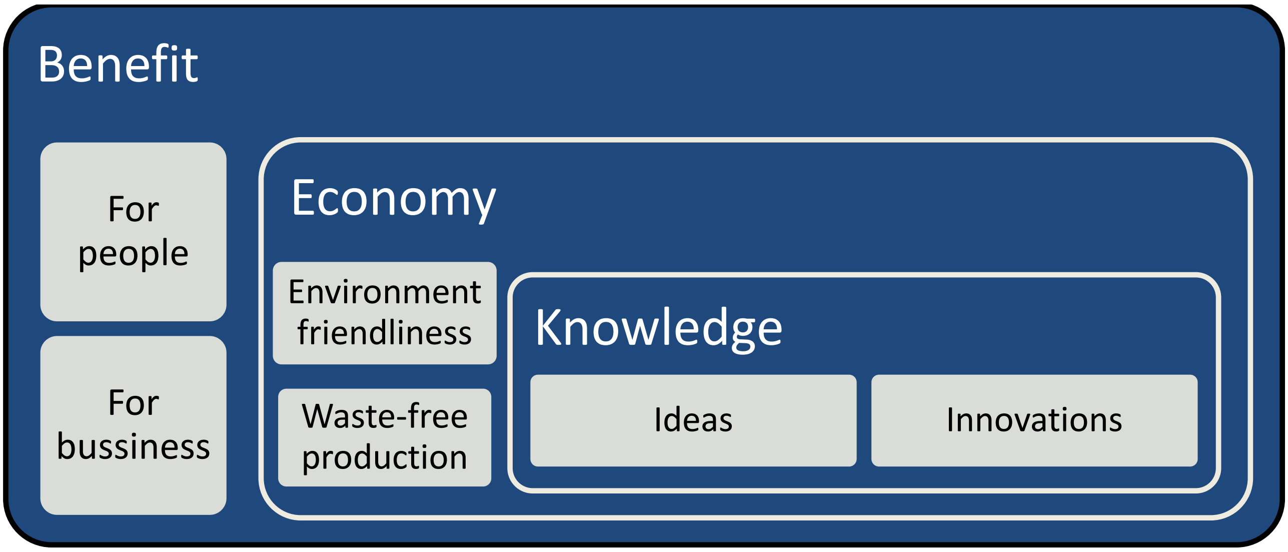


Figure. 11. The beneficial effect of the Blue Economy
Source: developed by the authors based on the general ideas of the Blue Economy

Any agricultural production requires large areas for sowing crops, so it is often based in rural areas. Villages, in turn, often do not have much choice of employment. Country people, who do not become successful entrepreneurs, often live short or go abroad to earn money. The development of rural communities is an increase in the population's purchasing power, in the revenue side of budgets, a better quality of life, a higher level of education, and opportunities in general. Furthermore, if new opportunities arise from the Blue Economy's symbiosis, this can be considered a double advantage.

Going back to Pauli's example of coffee and mushroom production, it should be noted that progress may arise from such cooperation. In particular, the author notes that the mushroom substrate, in turn, is a portion of good food for animals. This provides additional opportunities for the development of animal husbandry to give families food and business purposes.

G. Pauli identifies many advantages in the model "cellulose-to-protein" (Table 2). The "cellulose-to-protein" model influences climate change and the achievement of sustainable development goals (Table 3).

Table 2

The advantages of G. Pauli's "cellulose-to-protein" model

For producer and consumer			For the planet		
▲	**Wealth**	Coffee provides a substrate for growing mushrooms	▼	**Energy**	Coffee waste does not require additional processing
▲	**Cleanness**	Ease of sowing and growing	▼	**Methane**	Reduction of greenhouse gases due to lack of waste decay
▲	**Spead**	Caffeine promotes the rapid growth of mushrooms	▼	**Pastures**	Available animal feed
▲	**Value**	Free raw materials	▼	**Logging**	Coffee waste can replace wood in some cases

▲	**Health**	Mushrooms do not contain fat but are rich in protein	▼	**Landfills**	Waste is used
=	**Food security**	Use of crop waste to create food	=	**Food security**	Use of crop waste to create food

Source: Pauli, 2010

Table 3

The impact of the "cellulose-to-protein" model on climate change and the achievement of sustainable development goals

Impact on climate change	Progress in sustainable development goals
Low energy consumption	Food security
Forest's preservation	Women's empowerment
Lower energy transportation costs	Children health improving
No landfills	Ecological balance
No methane	Global partnership
Reducing the use of charcoal	Reducing the incidence
Cultivation of Slow Food	Self-sufficiency training

Source: Pauli, 2010

In recent years, Pauli's idea has been developed in the scientific literature. As a result, more and more researchers are looking for the best way to make the most of nature without harming the environment and other people. In particular, Geraldo Cardoso De Oliveira Neto et al. (2021) has considered the reuse of water and materials as a cleaner production practice in the textile industry contributing to the Blue Economy; Henrricco Nieves Pujol Tucci et al. (2021) has accessed the economic and environmental performance in the aircraft refueling process due to the principles of the Blue Economy; Juan Pablo Morea (2021) has investigated the post COVID-19 Pandemic Scenarios in an Unequal World Challenges for Sustainable Development in Latin America.

Thus, the Blue Economy can answer some questions (Figure 12)

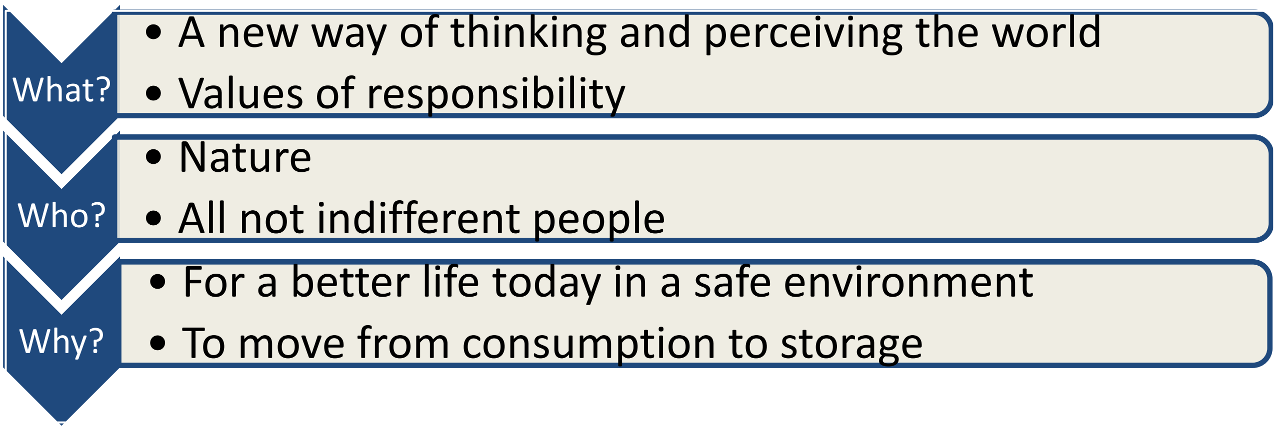


Figure 12. Questions which Blue Economy can answer
Source: developed by the authors based on the general ideas of the Blue Economy

The future of the world is in the Blue Economy. This is the only way how humanity can survive and develop in the long run. The health of our planet depends on us. Furthermore, even if the damage has already been done, nature knows how to heal wounds - we just need to allow it to do this.

Some factors have a positive impact on stimulating the establishment of the Blue Economy, in particular:

1. Understanding of personal responsibility for one's own and the planet's destiny.
2. Development of quality education for sustainable development.
3. Promotion of science and innovative ideas among young people.
4. Formation of a critical mass of socially responsible business.
5. State, local governments, and patrons' support (Figure 13).

According to Gunter Pauli, the Blue Economy power offers quality products at a low price and returns money back to the local product creation source. When the global supply chain of food implies that up to 90 percent of all the value-added generated in the supermarkets is spent on transportation, hardly any transportation is required, costs are reduced, margins are improved, and prices to the consumer are lowered A green battery does not replace a usual one; an energy system simply substitutes it for mobile electronic devices and power storage that does not rely on metal-based (and mining-driven) batteries. This represents massive savings in material and costs while reducing the ecological footprint on the environment and the health risks to the citizens of this world. The Blue Economy is not tailored to the large corporations, which have an established business model that will be hard to change (Pauli, 2021).

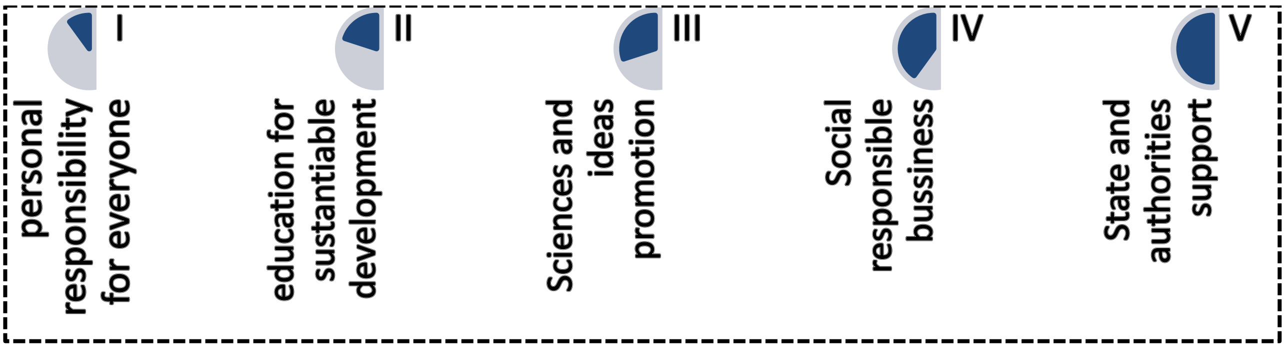


Figure 13. Factors, which positively impact on stimulating the establishment of the Blue Economy

Source: developed by the authors based on the general ideas of the Blue Economy

The low salaries of Ukrainians have left their mark on our perception of reality. Here we can even look for the roots of our perception of reality in the scarce past. All this in a complex has developed in some Ukrainians a particular set of worthlessness: it is not for us; it is for the rich; we will not be able to do so; it will not work for us, and so on. However, the Blue Economy's concept allows us to believe in our strengths and local capabilities, to achieve significant development even in depressed areas. The world is full of opportunities; we just have to use them. Nevertheless, this all depends on us, so we should not look for instant immediate results. Instead, it will be much more efficient to enjoy ours "today" in the big "blue" world.

REFERENCES

1. *World population 2021 (2021).* Retrieved from: https://www.worldometers.info/world-population/ (Last accessed: 15.07.2021).
2. *McNamara A. (2020). Global population predicted to peak by 2064.* Retrieved from: https://www.sciencefocus.com/news/global-population-predicted-to-peak-by-2064/ (Last accessed: 15.07.2021).
3. *Interaktyvna mapa administratyvno-terytorialnykh odynyts Ukrayiny (2020). [Interactive map of administrative-territorial units of Ukraine].* Retrieved from: https://atu.decentralization.gov.ua/#buttons (Last accessed: 15.07.2021).
4. *Ritchie H. (2019). Half of the world's habitable land is used for agriculture.* Retrieved from: https://ourworldindata.org/global-land-for-agriculture (Last accessed: 15.07.2021).
5. *World could face "hunger pandemic" in 2021, World Food Programme head warns (2020).* Retrieved from: https://www.nzherald.co.nz/world/world-could-face-hunger-pandemic-in-2021-world-food-programme-head-warns/2ZNCOY3HOVZYF7O6KDTFYI27Z4/ (Last accessed: 15.07.2021).
6. *Ekokakulyator (2021) [Ecocalculator].* Retrieved from: http://ecoosvita.org.ua/calc (Last accessed: 15.07.2021).
7. *Climate Action Tracker, "Methodology Note", CAT Climate governance series, (2020).* Retrieved from: https://climateactiontracker.org/documents/839/2020-12_CAT_ClimateGovernance_Methodology_Note.pdf (Last accessed: 15.07.2021).
8. *Fostering Effective Energy Transition 2021 edition (2021).* Retrieved from: http://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2021.pdf (Last accessed: 15.07.2021).
9. *Russian export (2020).* Retrieved from: https://oec.world/en/profile/country/rus/ (Last accessed: 15.07.2021).
10. *What is the Blue Economy? (2017).* Retrieved from: https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy (Last accessed: 15.07.2021).
11. *A new approach for a sustainable Blue Economy in the EU (2021).* Retrieved from: https://ec.europa.eu/oceans-and-fisheries/ocean/blue-economy/sustainable-blue-economy_en (Last accessed: 15.07.2021).
12. *Ritchie H., Roser M. (2019). Clean water and sanitation.* Retrieved from: https://ourworldindata.org/water-access (Last accessed: 15.07.2021).
13. *Pauli G (2010) 10 years, 100 innovations, 100 million jobs.* Retrieved from: https://www.gunterpauli.com/books1.html (Last accessed: 15.07.2021).
14. *Father Godfrey Nzamujo - The Man Behind Songhai Centre.* Retrieved from: https://mtfc.crenov8.com/news/father-godfrey-nzamujo-the-man-behind-songhai-centre/ (Last accessed: 15.07.2021).
15. de Oliveira Neto, G. C., da Silva, P. C., Tucci, H. N. P., & Amorim, M. (2021). Reuse of water and materials as a cleaner production practice in the textile industry contributing to Blue Economy. *Journal of Cleaner Production*, *305*, 127075. DOI: 10.1016/j.jclepro.2021.127075

16. Tucci, H. N. P., de Oliveira Neto, G. C., Rodrigues, F. L., Giannetti, B. F., & de Almeida, C. M. V. B. (2021). Six sigma with the Blue Economy fundamentals to assess the economic and environmental performance in the aircraft refueling process. *Renewable and Sustainable Energy Reviews*, *150*, 111424. DOI: 10.1016/j.rser.2021.111424
17. Morea, J. P. (2021). Post COVID-19 pandemic scenarios in an unequal world challenges for sustainable development in Latin America. *World*, *2*(1), 1-14. DOI: 10.3390/world2010001
18. *Pauli G (2021) The Blue Economy.* Retrieved from: https://www.gunterpauli.com/the-blue-economy.html (Last accessed: 15.07.2021).

II. HUMAN RESOURCES MANAGEMENT IN THE GREEN ECONOMY

2.1. Features of human resources policy in the «green» economic model

Olha Doronina
Doctor of Sciences (Economics),
Professor, Head of the Department of Management and Behavioral Economics,
Vasyl Stus Donetsk National University
E-mail: o.doronina@donnu.edu.ua
ORCID ID 0000-0001-7430-4881

The spread of the green economy in Ukraine and the world, the formation of a new ("green") economic model actualizes the transformation of traditional approaches to the management of available resources and tools for its practical implementation. In recent decades, it has been unequivocally proven that the leading resource for growth is human resources, which are recognized not only as a competitive advantage, a source of innovation and social development, but also have an important mission - to support the philosophy of "green" business.

"Green", or environmental business is a diversified area of business, which can provide not only environmental but also significant economic effect on a national scale [5, p.57]; it is a commercial activity aimed at making a profit from the sale of environmental goods and services, the production and provision of which involves the use of methods and technologies that minimize the integrated eco-destructive impact on the environment, and their use contributes to creating the most environmentally friendly living conditions for consumers. and in the long run [5, c.59].

Human resources are identified by scientists as specific and the most important of all types of economic resources; as a factor of economic development, human resources are employees who have certain professional skills and knowledge and can use them during the labor process [1, p. 68]. Human resources are a set of human qualities (socio-demographic, educational-professional, motivational, mental, intellectual, spiritual-informational, innovative, creative, cultural, ethno-social, socialization, etc.) that determine a person's ability to labor, consumption of material and spiritual goods, self-development, creation of innovations, increase of knowledge in all spheres of human activity [7, c.11].

An applied tool for human resource management is personnel policy, which should be relevant to the current economic model, and, accordingly, acquires new meaning and is transformed in accordance with the principles of the green economy. The concept of «personnel policy» is quite ambiguous and complex, in the management sphere it is used in a broad and narrow sense. In accordance with the developments of modern economics and management science, we consider more acceptable a synthetic approach to the definition of «personnel policy», which more fully reveals its essential purpose. Personnel policy is a set of principles, methods and forms of organizational mechanism for the formation, reproduction, development and use of personnel, the creation of optimal working conditions, its motivation and incentives; system of theoretical views, ideas, requirements and principles that determine the main directions of work with human resources [2, p.42].

Personnel policy in a green economy is proposed to be defined as a system of goals, principles and interrelated elements of management human resources, which is part of the overall strategy of the business entity and is aimed at ensuring human development in compliance with the principles of green economy. The green economy is proclaimed at the global level as an economy that promotes human well-being and strengthens social justice while significantly reducing risks to the environment and the scarcity of environmental resources [5, p. 21]. Among the priorities of the green economy is the well-being of all people. Thus, the goals of the «green» economy and personnel policy are closely interrelated and aimed in the long run at sustainable development and the development of decent work.

If the purpose of traditional personnel policy is related to staffing the current and future goals of the business entity, the purpose of personnel policy in a green economy is to support a «green» economic model through human resources development and the spread of decent work. In turn, decent work means work in conditions of freedom, equality, security and respect for human dignity [4, p. V]. The key characteristics of decent work are:

1) productivity;
2) security;
3) respect for workers' rights and social protection;
4) appropriate income; {{ 1}} 5) the ability to influence decisions on working conditions and labor relations through social partnership.

In the conditions of "green" economic model the formation of personnel policy on the basis of decent work remains relevant, which is defined as a system of principles, methods, rules and tools of human resources management aimed at ensuring sustainable development, macroeconomic stability, improving the quality of life. women of decent and productive work in conditions of freedom, justice, security and human dignity [3]. Characteristics of personnel policy are shown in Fig. 14.

Depending on the level of implementation of human resources management tools, there are:

1) state personnel policy;
2) regional personnel policy;
3) corporate personnel policy.

State personnel policy is a system of officially recognized goals, objectives, priorities and principles of the state in regulating personnel processes and relations [3]. Ukrainian legislation proclaims the goal of the state personnel policy to provide all spheres of life of the state with qualified personnel necessary for the realization of national interests in the context of Ukraine's development as a democratic, social state with a developed market economy [9]. The main components of the state personnel policy are: demographic policy, policy in the field of education and employment, social policy.

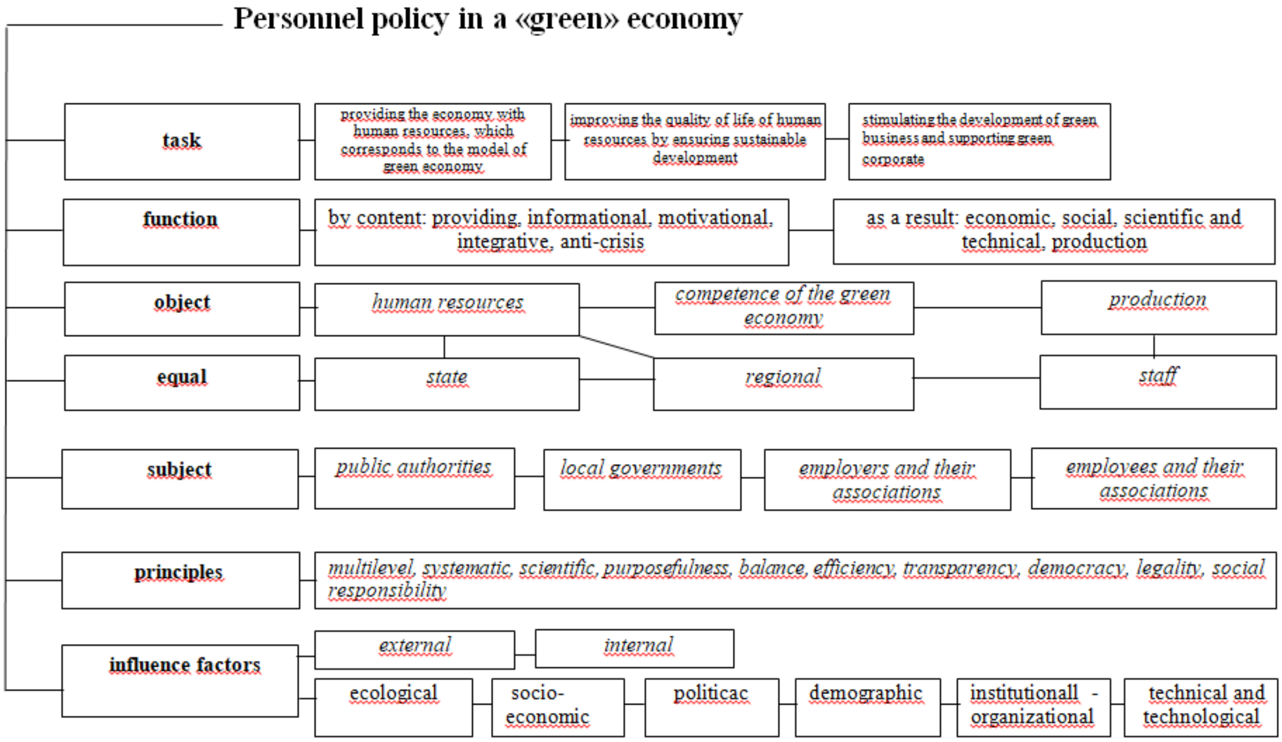


Fig. 14. Essential characteristics of personnel policy
Source: developed by the author

In the context of the effectiveness of the state personnel policy of Ukraine in the "green" economic model, it is advisable to pay attention to the assessment of such indicators of "green" growth as [5, p.108]:

- indicators of environmental aspects of quality of life, namely indicators health status of the population (average life expectancy at birth, average life expectancy at birth, the growth rate of the most common diseases in Ukraine);
- socio-economic conditions and characteristics of growth, namely, population (population, population forecast until 2050) and the labor market (level of economically active population (labor force participation) aged 15-70 years, employment rate aged 15-70 years and the unemployment rate of the population aged 15-70 (according to the ILO methodology)).

Regional personnel policy is a set of rules and principles for the formation, development and rational use of human resources in the region in order to ensure its innovative development in the future [3, p.35]. It is a means of implementing the strategy of state personnel policy at the regional level. In modern conditions, regional personnel policy must meet a number of requirements, the most important of which are: regional personnel policy, which must be closely linked to public personnel policy, be scientifically sound and active, systematic and comprehensive, it must be proactive and preventive, and multilevel (cover all personnel processes).

Characteristic features of the personnel policy of the region depend on [8]: the uniqueness of material, natural and human resources of the region; certain socio-economic parameters of the region; the ability to flexibly adapt to changes in the state (external environment) and the region (internal environment); the balance of goals and objectives of the state and the region.

In addition, in the "green" economic model, the specifics of the formation of regional personnel policy should be determined depending on the prevalence of "green" sectors of the economy in the region, the provisions of program and strategic local documents. Corporate personnel policy (personnel policy of the enterprise) is a general direction of personnel work, a set of principles, methods, forms, organizational mechanism for developing goals and objectives aimed at preserving, strengthening and developing human resources, creating a qualified and highly productive team capable of timely respond to ever-changing market demands, taking into account the development strategy of the organization " [10, c. 188]. Its purpose is to form a highly productive, highly professional, cohesive team, in particular, motivated to work on the basis of the principles of «green» economy.

The main principles of the «green economy», which, in our opinion, should be taken into account in the formation and implementation of personnel policy include:

- equality and justice within one generation and between generations;
- compliance with the principles
- caution about social consequences and environmental impact;
- understanding the high value of natural and social capital;
- resource efficiency, sustainable consumption and production;
- the need to meet macroeconomic goals in a way to create "green" jobs, increase competition and growth in key industries [5, c.22].

Substantive corporate personnel policy includes the following components: personnel selection and adaptation policy; personnel evaluation policy; personnel development policy; personnel investment policy; personnel incentive policy; production relations policy; labor organization policy; corporate social policy. In terms of development " green "economic model for all levels of government, it is advisable to offer a certain algorithm for the formation of personnel policy (Fig. 15).

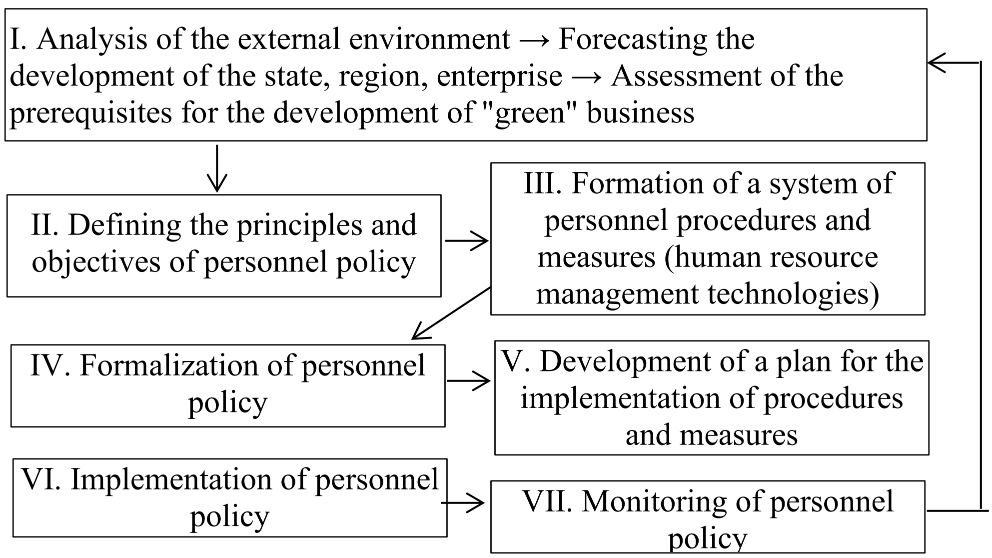


Fig.15. Algorithm for forming personnel policy in a «green» economy
Source: developed by the author

When implementing this algorithm, management entities should take into account that in the human resources management system under the development of "green" economic model are the following processes:

- change in the structure of employment by type of economic activity (employment growth in "green" rural economy, "green" energy, "green" industry, areas related to energy efficiency, waste management, biodiversity conservation, development of "green" infrastructure and the corresponding reduction of employment in such activities as oil, coal, etc.);
- growth of labor market demand for professions and specialties related to the development, implementation and operation of "green" technologies, which provides for appropriate changes in education - the opening of new educational programs, changing the structure of the state order for training, etc.;
- increasing the number of «green» jobs and updating the new list of competencies of staff of «green» companies;
- transformation of corporate motivation systems in the direction of encouraging staff to support the «green» corporate culture and adherence to the principles of enterprise (company) «green» business, as well as ensuring the adaptation of staff in the transition of business to "green" principles.

These trends are confirmed, in particular by the following data. Achieving the 20% renewable energy target could have a net effect of creating around 417,000 additional jobs in the EU labor market; similarly, achieving a 20% energy efficiency target could increase net employment by about 400,000 jobs. Increasing the growth rate of water management in Europe by 1% can create from 10 thousand to 20 thousand new jobs. Tourism and recreation at Natura 2000 sites are estimated to directly support about 8 million jobs [6, c.68].

Thus, the features of the "green" economic model and the principles on which the "green" business is based determine the features of personnel policy, its tools and mechanisms at the state, regional and corporate levels. Transformation of approaches to the formation and implementation of personnel policy will contribute to both resource support for the development of a "green" economy and the development of human resources on the basis of decent work.

REFERENCES

1. Grishnova O.A.(2009). Economics of labor and social-labor relations: a textbook. 4 types. Kyiv: Knowledge. 390p.
2. Dovgan L.S., Karakay Y.V., Simchenko N.O. (2009). Modern technologies of human resources management of the organization: monograph / L.S. Dovgan, Y.V.. - Kyiv: Center for Educational Literature. 320p.
3. Doronina O.A.(2013). Theory and practice of formation of multilevel personnel policy in the context of ensuring decent work in Ukraine: monograph. Donetsk: DonNU. 395 p.

4. Decent work: report of the Director-General of the Office (1999). 87th session of the ICC. - Geneva.
5. Galushkina T.P, Musina L.A., Potapenko V.G. Basic principles of implementation of the model of "green" economy in Ukraine: textbook. Way (2017); for science. ed. T.P. Galushkina. - Kyiv: Institute of Environmental Management and Balanced Nature Management. 154 p.
6. Plisenko G.P., Nazarkevich V.O. (2019). Trends in the development of the "green" economy in the European Union and their impact on the labor market: experience for Ukraine. Priazovsky Economic Bulletin. Issue 5 (16). WITH. Pp..65 – 69. DOI: https://doi.org/10.32840/2522-4263/2019-5-7.Semiv L.K. (2004). Regional policy: human dimension / LK Semiv. Lviv: Lviv Polytechnic National University. 392 p.
7. 8.Sidunova G.I. Personnel policy of the region: an innovative approach. URL: http://www.smartcat.ru.
8. 9.Decree of the President of Ukraine № 45/2012 of 01.02.2012 "On the Strategy of State Personnel Policy for 2012-2020".URL: http://zakon.rada.gov.ua.
9. 10.Kibanov I.Ya. (2004). Personnel management of the organization: textbook. M.: ИНФРА – М. 638 p.

2.2.Development of the labor market in a green economy

Maryna Naumova
PhD (Physics and Mathematics)
Head of the Department of Economic
and Management Analytics
Vasyl' Stus Donetsk National University of Vinnytsia
E-mail: m.naumova@donnu.edu.ua
ORCID: http://orcid.org/ 0000-0002-1333-8022

A new trend in the modern labor market is the development of policies to promote employment based on the principles of green economy. The key direction of such policy is the formation of an environmentally oriented labor market by creating green jobs that help reduce negative impact on the environment and improve the environmental situation [1]. A new direction of research and assessment of economic and social factors of sustainable development in the context of environmental protection emerged in the early 1980s, resulting in the analysis of labor market problems in the green economy.

Currently society has different interpretations of the essence of the expression "green" economy. Those include new sectors of economy or new technologies that can improve the environment of the planet, create environmentally friendly products.

All approaches to the definition of "green economy" are very close and define the economy, which aims to preserve the well-being of society through the efficient use of natural resources, ensures the return of end-use products in the production cycle. First of all, the green economy is aimed at the economical consumption of those resources that are currently prone to depletion and rational use of inexhaustible resources. At the heart of the green economy are "clean" or "green" technologies. According to experts, the development of a green economy will avoid the world's environmental crisis, which has already begun its onset on a global scale.

UN sustainable development experts define green economy as an economy with low carbon emissions, efficient use of its resources, and socially inclusive [2]. According to UNEP documents, the green economy increases people's well-being, ensures social justice and at the same time significantly reduces risks to the environment. It must maintain the natural environment while ensuring equal access to environmental goods, supporting the people who consume these goods, promoting employment, and providing and encouraging work that contributes to the protection of the environment.

Failure to address important environmental issues will not only have adverse effects on the environment but can also have a negative impact on human health and economic development. Climate change, air pollution and irrational use of natural resources directly or indirectly affect all sectors of the economy and can affect the prospects for long-term economic growth. The Paris Climate Agreement, approved by the Climate Conference on 21 December 2015, identifies climate change as one of the greatest threats to sustainable development in the 21st century [3].

Changing the policy of states to protect the ecological system will avoid the risks of environmental degradation, prevent deterioration of health and support economic growth in the long run. An important goal of environmentally oriented policy should be the formation of legal, economic and institutional conditions conducive to employment in the labor market on the basis of green jobs, the formation of competencies in the field of resource conservation and more. It should be noted that the green economy is one of the drivers of sustainable development, it will not replace a sustainable economy.

Until a few years ago, the green economy consisted exclusively of politicians in environmental area, alternative energy companies and researchers. It has now spread to different types of industries, as more and more sectors move towards sustainable development goals. Activities to improve the environment, conserve natural resources, energy and resource conservation, production of environmentally friendly products, waste processing, development of organic farming, implementation of green standards is becoming a factor that promotes economic growth, expands employment and creates new jobs [4].

One of the most important areas of environmental policy is the development of "green employment", which means a set of socio-economic measures aimed at forming an efficiently functioning labor market while reducing the negative impact on the environment.

The question of strengthening the relationship between employment, jobs and the possible destruction of the environment was first raised in the work of the Swiss economist H. K. Binswanger "Work without the destruction of the environment. Strategies of the new economic policy" [5], which considered the possible negative consequences of environmental pollution in the labor market. Since then, the green economy and its impact on the functioning of the labor market has become a driver of research and policy-making in many international organizations and countries.

According to ILO experts' forecast, the transition to a green economy will affect at least half of the world's workforce, or 1.5 billion people. For this reason, the Green Jobs Initiative [6] was incorporated into the Seven Centenary Initiatives of ILO [7] proposed by the ILO Director-General in 2012 in connection with the forthcoming celebration of the centenary of this organization. The document emphasizes that "More than 1.2 billion jobs depend on a stable environment and ecosystems. The Green Initiative aims to scale up the ILO's knowledge, policy response and capacity to manage just a transition towards greener economies and a sustainable future". The Green Jobs Initiative aims to intensify the work of all units to spread the knowledge, consult and develop tools for the transition to a low-carbon economy of the future.

The impact of the green economy on the development of labor markets can be both positive, creating new opportunities for workers, as well as quite risky. The structure of labor demand will differ for various sectors of the economy, different skills of workers, countries and regions, depending on environmental policy and its instruments. Simultaneously with the change of policy to environmentally oriented, the functioning of the labor market will be affected by technological, economic and demographic trends that are inherent to national economies, which will create additional challenges for the labor market.

Effective threat management in the transition to a green economy will create new opportunities for many workers. New jobs will be created in the green sectors, while in the "brown" sectors the number of jobs will gradually decrease. In other sectors of the economy, the impact on employment can also be significant. It is still not possible to say for sure about the numerical impact on the labor market of the consequences of the transition to a green economy, but according to preliminary calculations of scientists, the policy of supporting the green economy should not harm overall employment. Its main task is to prepare the labor market for the transition to the green economy. According to the EU Development Strategy "Europe 2020", the goals of the green economy include environmental employment of the population aged 20 to 64, as well as reducing the number of people living below the poverty line by 25% [8]. At the same time, ecological employment is a new type of employment associated with the elimination of accumulated damage to the ecological system, processing of solid waste, introduction of ecological innovations, and so on. In other words, it is an activity that generates income and does not contradict the law, reduces the negative impact on the environment.

The purpose of environmentally oriented policy is to create legal, economic and institutional conditions that can ensure employment in the labor market on the basis of green jobs, the formation of competencies in the field of resource conservation and others in the transition to an environmentally friendly economy.

As stated in the study Report «Green Jobs: Towards decent work in a sustainable, low-carbon world» [9] «we define green jobs as work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution».

The main directions of creating green jobs include the formation of new means of economic development related to environmental protection, rational use of natural and energy resources, reduction of greenhouse gas emissions, disconnection of environmental technologies, waste processing and disposal, production of environmentally friendly products, business which creates conditions for green employment.

The concept of a green workplace is associated with the use of environmentally friendly technologies, the production of environmental goods and the creation of an environmentally friendly product, as well as the maintenance of green production. That is, green jobs can be determined by both production and production processes.

At the same time, green jobs must meet many criteria, such as improving the quality of the environment, the use of innovative technologies, reducing energy consumption, reducing waste, human resources development, safe working conditions, respect for workers' rights and others. In a broader sense, green jobs can be understood as jobs that are related to environmental rehabilitation, reducing the load on natural systems through waste recycling, elimination of accumulated environmental damage, restoration of disturbed lands, sustainable use of nature, production of environmental goods, services in this field, etc. The set of criteria to characterize the green jobs from different angles is presented in Figure 16. According to the International Labor Organization, the transition to a green economy can create between 15 and 60 million jobs worldwide [10], which will reduce unemployment and help preserve the environment.

As a result of "greening" the labor market it is expected to see an increase in employment in many countries [1], namely: in Australia - the creation of 6.6 million jobs by 2050 in the green economy (energy, industry, transport, construction); in Brazil - an annual increase in employment in the green economy by 1.13% in the period up to 2030; in China - 6.8 million jobs in the fields of wind and solar energy, hydropower by 2030; in Indonesia - 1.2 million jobs in the fields of green energy, green transport, forestry by 2030; in South Africa - 0.5 million jobs in the field of green energy by 2025. As stated in the study [11], «Through the Low Carbon and Environmental Goods and Services Sector (LCEGSS) dataset, the US green economy is estimated to represent $1.3 trillion in annual sales revenue and to employ nearly 9.5 million workers; both of which have grown by over 20% between 2012/13 and 2015/16. Comparison with China, OECD members and the G20 countries suggests that the US is estimated to have a greater proportion of the working age population employed (4%) and higher sales revenue per capita in the green economy».

The WBCSD Overview states that «the buildings and construction sector is highly energy-demanding and carbon-intensive, accounting for 39% of global energy-related CO_2 emissions. Construction and demolition is one of the heaviest and most voluminous waste sources. In many countries construction and demolition waste accounts for up to 40% of all municipal solid waste with a significant part of it ending up in landfills. It is important to emphasize that it already makes business sense to build green. Green buildings have a lower operational cost than traditional ones and their asset value is around 10% higher» [12].

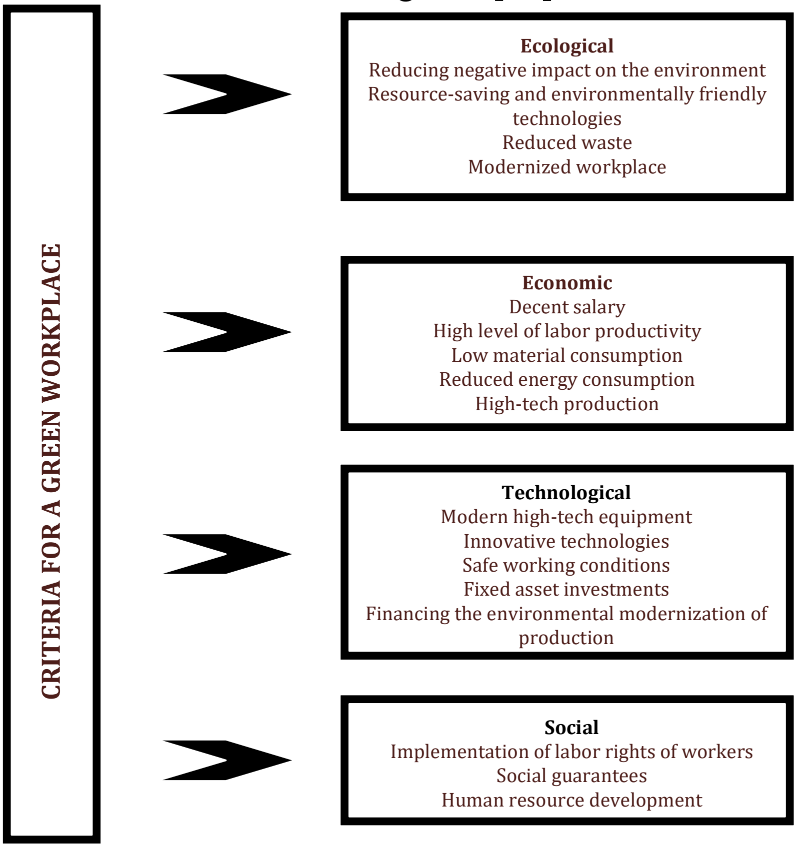


Figure 16. The main criteria of a green workplace

Source: Developed by the author based on the ILO report by the Green Jobs Initiative (2012), World Employment and Social Outlook 2018: Greening with jobs

Green economy technologies are already increasing the demand for professions that emerge in the process of transition to green production, and professions that already exist but are being modernized to the new requirements of the green workplace. With the introduction of a new environmentally oriented policy there is a need to hire managers, engineers, lawyers, auditors. Solar panel companies need installation experts, salespeople, marketers and other staff. Therefore, the reorientation of production to the ecological type opens up great opportunities for the development of the labor market. The key drivers of creating green jobs are: reducing the negative impact on the environment, creating a new environmentally friendly innovative products, ways of production for use in other economic activities, promoting the creation of green jobs in other economic activities. Engineers, technicians, scientists, designers are the leaders of the green economy. Transition to environmentally friendly building materials will create a demand for qualified contractors and builders who know how to work with these materials. Scientists who can predict the biological response to environmental degradation are needed to understand the effects of climate change and other ecosystem research. Examples of new professions related to the development of the green economy are given in Table 4.

Table 4

New professions related to the development of the green economy

Management/Entrepreneurship	Renewable energy manager
	Green business manager
	Forestry/land manager
	Recycling and waste manager
	Energy auditing
	Solar energy entrepreneurs
Technicians	Solar panel technicians
	Waste recycling technicians
	Technology installers
	Wind power technicians
	Biofuel technicians
	Energy consultant in low carbon economies
	System mechanics
	Wave power workers
	Clean car mechanics
	Water quality technicians
Builders	Green housing builders
	Green commercial builders
	Eco-friendly furniture builders
	Retrofitters
Engineers and designers	Electric car engineers
	Renewable energy engineers
	Shipbuilding to wind turbine manufacture
	Sustainable building design
	Green urban planning
	Eco-friendly landscaping design
Scientists	Marine biologists
	Climate researchers
	Geologists
	Botanists and horticulturalists
	Policy advocates and regulators

Source: Developed by the author based on World Employment and Social Outlook 2018: Greening with jobs, Going Green: Preparing the UK workforce for the transition to a net-zero economy (2020)

In the transition to a green economy, the qualitative characteristics of employment are transformed. In green jobs, workers are required to have a higher level of education, work experience and highly qualified training compared to those employed in "brown" jobs. Renewable energy and sustainable technologies need qualified professionals. Training and retraining of professionals should be central to the green economy.

For a large proportion of workers working in the green economy, there is a need to combine the existing set of skills and competencies with additional ones related to green technologies or production processes. But with the emergence of new professions, there will be a need to form radically new areas of professional experience and knowledge, which will lead to the need to reform and modernize the education system and provide opportunities for lifelong learning. Along with Hard Skills and Soft Skills, special attention should be paid to the development of certain competencies in the focus of environmental education and digitalization, inextricably linked, such as environmental awareness, environmental culture, the ability to make environmentally sound decisions, etc. (Fig. 17). Moreover, the formation of such competencies should become mainstream in lifelong learning, from primary education to adult learning. No less important aspect of environmental education is practice-oriented, the involvement of practitioners in the organization of educational activities.

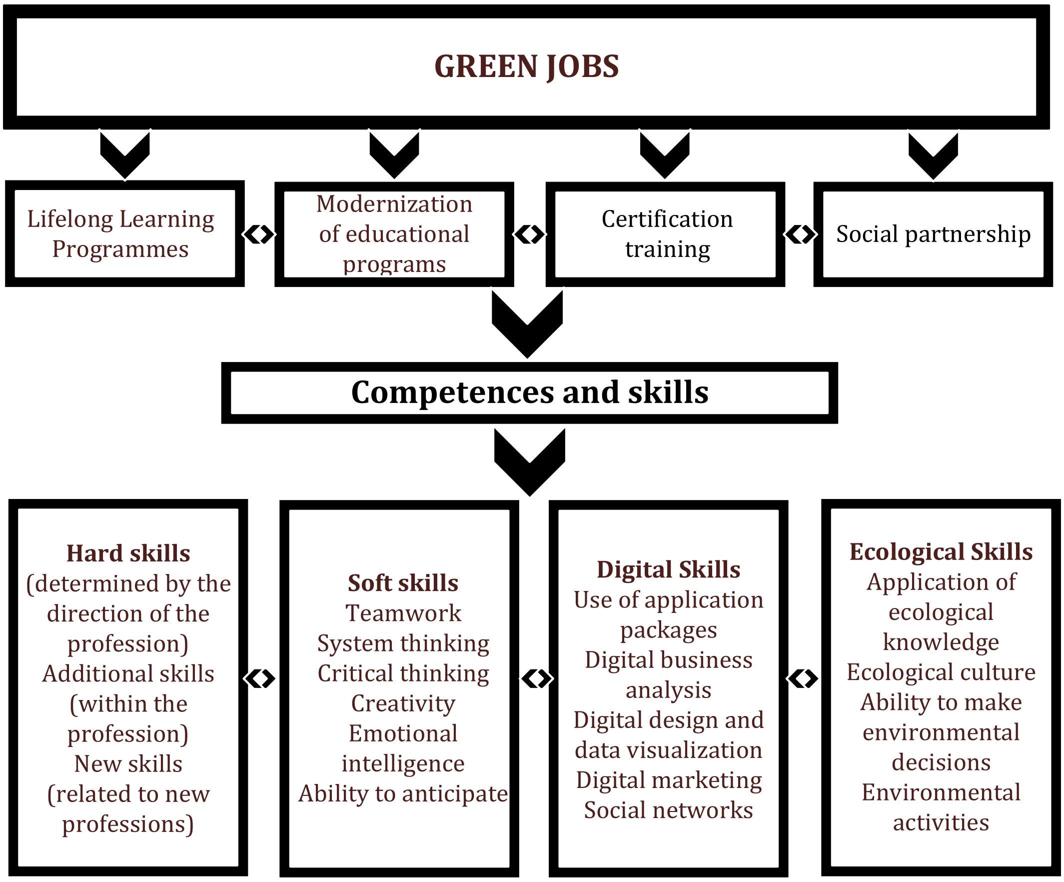


Figure 17. Skills and competencies of the employee in the green economy

Source: Developed by the author based on the ILO synthesis report based on 21 country studies "Skills for Green Jobs: A Global View" (2011), ILO report "Skills for Green Jobs" (2015), Skills for green jobs: 2018 update (Cedefop)

The priority program for Ukraine's development in the field of "green economy" was the program "EaP GREEN" in 2013-2017, which was aimed at assisting six countries of the Eastern Partnership of the European Union to transition to a "green" economy: Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine [13]. The main areas of the program were: management and financing, the use of strategic environmental assessment and environmental impact assessment, increasing human and institutional capacity in the field of resource-efficient and cleaner production.

Since 2019, Ukraine, together with the other five countries of the Eastern Partnership in the transformation of the economy in the direction of greening, is supported by the EU-funded program "Environment 4" on environmental issues [14]. One of the expected results of the program to support economic growth is to reduce poverty and create new jobs.

REFERENCES

1. Sustainable development, decent work and “green” jobs. Report V. International labour conference, 102nd Session. International Labour Office. Geneva, 2013, pp. 23–27. URL: http://www.ilo.org/wcmsp5/groups/public/ed_norm/relconf/documents/meetingdocument/wcms_207370.pdf.

2. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. United Nations Environment Programme, 2011. P. 16. URL: https://warwick.ac.uk/fac/soc/pais/research/researchcentres/csgr/green/foresight/energyenvironment/2011_unep_towards_a_green_economy.pdf.

3. Adoption of the Paris agreement. FCCC/CP/2015/L.9/Rev.1. URL: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

4. Miklós Antal. Green goals and full employment: Are they compatible? Ecological Economics, 2014, vol. 107, issue C, 276-286. URL: https://econpapers.repec.org/article/eeeecolec/v_3a107_3ay_3a2014_3ai_3ac_3ap_3a276-286.htm.

5. Binswanger H. K. Arbeit ohne Umweltzerstoerung. Strategien einer Wirtschaftspolitik. Frankfurt am Main, S. Fischer Verlag, 1983. 367 p.

6. The Green Initiative. ILO https://www.ilo.org/global/about-the-ilo/history/centenary/WCMS_467270/lang--en/index.htm.

7. ILO centenary initiatives. https://www.ilo.org/global/about-the-ilo/history/centenary/lang--en/index.htm

8. Europe 2020. A European strategy for smart, sustainable and inclusive growth. European commission. Brussels, 2010. P. 3, 8–9. URL: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf.

9. Green Jobs: Towards decent work in a sustainable, low-carbon world. UNEP, ILO, OIE, ITUC, 2008. P. 3. URL: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf

10. Working towards sustainable development. Opportunities for decent work and social inclusion in a green economy. A report by the Green Jobs Initiative / International Labour Organization. Geneva, 2012. URL: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_181836.pdf.

11. Lucien Georgeson, Mark Maslin. Estimating the scale of the US green economy within the global context. Palgrave communications. 2019. URL: https://www.nature.com/articles/s41599-019-0329-3.

12. The construction sector can pave the way for a green economic recovery. The WBCSD Overview. URL: https://www.wbcsd.org/Overview/News-Insights/WBCSD-insights/The-construction-sector-can-pave-the-way-for-a-green-economic-recovery.
13. EaP GREEN. URL: http://www.eap-green.org/countries/ukraine/.
14. Towards a Green Economy in Ukraine. EU4Environment Work in Progress – 2019-20. URL: file:///D:/Downloads/Ukraine-country-profile-2020-21-second-edition_0.pdf

2.3. Human resources intellectual assets and digital skills in a green economy and industry 4.0

Andrii Karpenko
Doctor of Sciences (Economics),
Professor of department of economics and customs,
National University «Zaporizhzhia Polytechnic»
E-mail: karpenko.a.v2@gmail.com
ORCID ID 0000-0002-5717-4349

In the conditions of modern transformations and innovative development of the global world economy, the possibilities of stable development of socio-economic systems are determined by their ability to generate innovative and qualitative changes, which is related to human well-being and development. Educational, intellectual, creative potential of man is increasingly recognized not only as a powerful factor in economic growth, but also a source of income at all levels of management: the individual, enterprise, state. This is especially true within the concept of a «green» economy, which for more than 20 years has remained open to discussion and continues to develop. It (the «green» economy) is associated with social justice, reducing the negative impact on the environment and increasing the efficiency of natural resources.

The term «green economy» when used in 2008 was actively used in the context of discussing anti-crisis policy, but today is recognized as an economy that improves human well-being and strengthens social justice while significantly reducing risks to the environment and scarcity of environmental resources. This proves that in the green economy man has a special place as both an object and a subject. Aristotle also noted the special creative abilities of man, which are formed under certain conditions of life, education and training. Understanding the priority of man among other assets of the enterprise (region, state), including material, was gradually manifested by various economists, but its perception as an object of investment that can bring some return, was already in the twentieth century.

In the developed world, about 90% of GDP is accounted for by new knowledge embodied in engineering and technology. This testifies to the intellectualization of the economy on the basis of an objective process of expanding the conditions for the use of intellectual and creative potential of people. The intellectual component of man is recognized as the most significant among others, the consideration and analysis of which allows to distinguish intellectual assets. That is, it is the part of human potential that is able to further capitalize and ensure the creation of added value. Such «elusive assets», which are the basis of intellectual capital, were noted by K. Bradley [1], E. Brooking [2], B. Leontiev [3] and others. It is their identification and transformation into useful resources that allows not only to increase income, but also to provide competitive advantages. Intellectual assets can be defined as an economic category that reflects the process of transformation of part of human potential capable of development and change capital of business units (Fig. 18).

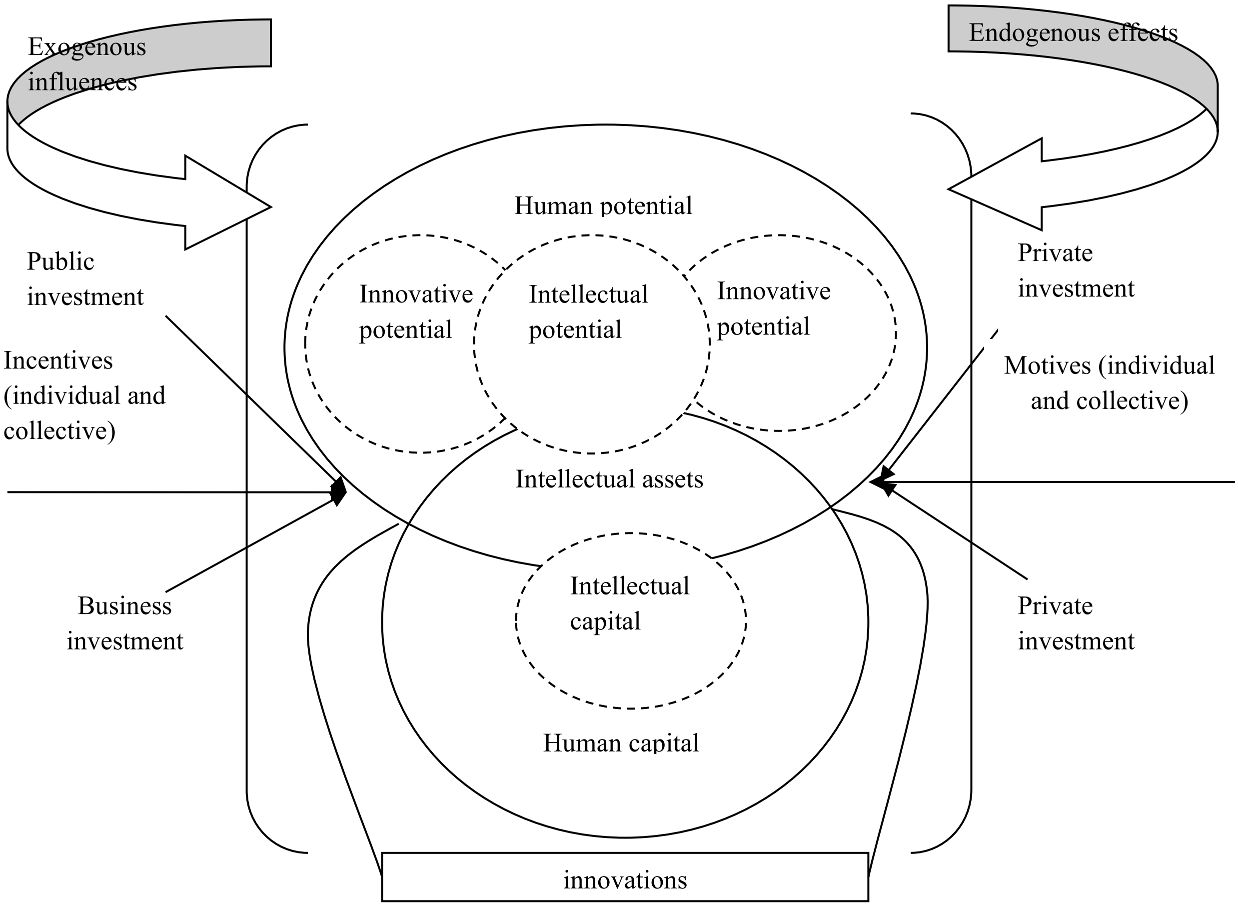


Fig. 18. Logical and structural scheme of formation and use of intellectual assets of human potential [4, p. 48]

The main features of assets are their, compared to others, the most active basis and tangible (or intangible) form in which capital is invested for possible future economic benefits and controlled by its owner. In particular, IA Blank, under the assets of the enterprise recognized the form of owner-controlled economic resources, which are formed at the expense of capital invested in them and have value and are able to generate income.

Under control, the author means: acceptance of risks associated with the use of assets; obtaining economic benefits from the use of assets; restricting access of other persons to such benefits [5, p. 19–20]. The criteria for recognizing intellectual assets

(IA) specified in international and domestic financial reporting standards are as follows: they must accumulate future economic benefits; must be controlled by the enterprise as a result of past events; the cost can be reliably estimated [6, p. 122]. Thus, intellectual assets are transformed under the influence of investment and used in production conditions a form of intellectual capital.

Unlike intellectual capital, intellectual assets are able to use their economic resources in future economic activities. That is, intellectual capital mainly reflects the products of the past accumulation of values, and intellectual assets - the future. Intellectual assets are characterized by two features: intangible form, because there is no possibility of their real assessment; material nature, as their unique properties make it possible to generate economic benefits not only today but also in the future. That is, scientists argue that they are related to human and intellectual potential.

Almost all associate intellectual assets with the acquired resources of the company, which have already been formed in the course of its activities and those that will be created in the future. Accordingly, they are the result of creative, research or inventive activity. Scientists recognize the creation of additional intangible assets by man. Man himself is a kind of asset, or, in other words, contains some of the features that can act as assets. However, there is no clear regulation in the literature that intellectual assets do not arise by themselves, but are the result of conscious (or even unconscious) their accumulation and use by an individual, company staff or the population. Since we are talking about resources that are created by man and the results of his intellectual work, it is important to note that the belonging of intellectual assets to human potential.

It is known that an asset takes the form of certain resources or property rights that belong to a natural or legal person and are able to provide economic benefits in the future. Intellectual assets are basically presented as those assets that are created through intellectual labor, characteristic of man. Each person (individual) has a certain intelligence and has the opportunity to increase and commercialize it. Human potential is characterized mainly as the potential of man or the population as a whole. Both assets and human potential are, so to speak, opportunities that can provide future income. Accordingly, it is necessary to identify these opportunities in humans, evaluate them and ensure their further development and implementation. 522–523] by the following key groups of concepts: ideas, knowledge and abilities of employees; part of intellectual capital; source of value creation, economic benefits; intellectual resources and valuable information; component of intangible assets of intangible origin; unique resources.

The special role of qualitative human traits in productive activity as a part of assets and a structural element of fixed capital was substantiated by A. Smith [8]. That is, intellectual assets belong to human potential. Accordingly, intellectual assets are not only those assets that have been identified and accounted for, but also those that remain potentially available for sale.

Intellectual assets of human potential can be identified as individual elements of human potential and the results of capitalization capacity in the process of activity. These are individual elements of human potential, which gradually accumulate and transform from birth in the process of education, cultural development and involvement in a healthy lifestyle, education and training, as well as intellectual performance.

Intellectual assets of human potential are considered as competencies (cognitive, emotional, creative), as they have an intangible nature, as well as the results of his intellectual activity (intangible and tangible form). They are formed as a result of investing in a person alone or by a company / state of money, material resources and knowledge, are characterized by deterministic value, productivity and ability to generate income, the constant circulation of which is influenced by time, risk and liquidity. The value of intellectual assets of human potential is determined by the knowledge, skills and experience of man (staff of the organization, the entire population). That is, they are a kind of reflection of the properties (competencies) of human potential and are characterized by the following features: formed and developed by investing money, material resources and knowledge; require maintenance and development costs; bring income to the owner; have an intangible nature; aimed at the future; are resources that are stored and renewed; the carrier and owner is a person (staff of the organization, the population).

Thus, there is reason to propose to define ILP as a unique type of resources - an integral component of human potential, which is transformed (integrated) into the structure of intellectual capital and based on special (rare and exceptional) economic resources, which is the result of intellectual creative, research and inventive activities and is able to provide future socio-economic benefits. At the enterprise level, intellectual assets not only increase its book value, but also provide its capitalization and the ability to attract additional investment resources.

Intellectual assets have a number of characteristic features: they are practically not subject to the risk of a collapse in value; presented in a special coded form; move quickly between different subjects of legal relations; at simultaneous use the consumer cost does not decrease; insignificant variable costs; conditional ownership; unique pricing; possible increasing return; almost not subject to wear (or moral); management methods - risk-oriented, etc. [9, p. 10–11]. Intellectual assets are classified on many grounds, including: socio-economic nature, purpose and types of costs for their creation; by area of creation, capitalization (accumulation) and use; by the environment of formation and accumulation; by frequency of use; by the method of creation; by potential, etc.

Intellectual assets of human potential are mainly based on the following elements: ideas; knowledge; talent; information; business reputation; image; intellectual capabilities of staff; products of intellectual labor. They are part of the general intellectual assets.

Intellectual assets of human potential in the process of their use provide concrete results of intellectual, mental, spiritual and creative activity, ie create intellectual products, the main component of which is knowledge. The production of knowledge and, consequently, its capitalization, commercialization and consumption require a special environment, which in a "green" economy must be provided by public and private investment, which reduces carbon emissions and pollution, increases resource efficiency and expands ecosystem services.

Intellectual assets - an integrated economic category, which includes those objects of intellectual capital that are already reflected in accounting (intangible assets), and those that should be included in the accounting system (customer relations, marketing, technology improvement, training and staff development, development of new products and services). They are presented in the accounting system (both financial and management) as purely costly, which contradicts their role in modern conditions [10]. Determining such assets and assessing their level in the enterprise can be the basis for identifying their unique niches in the local or other markets, which can provide the company with additional competitive advantages, allow to obtain additional profits. Intellectual assets allow to increase the level of capitalization, and in the absence of sufficient financial resources and collateral to provide the investor with additional guarantees of return on capital.

The content of the category "intellectual assets of human potential" should be disclosed in the following provisions: first, intellectual assets as a specific component of human potential are a set of cognitive, creative, emotional competencies of economically active population, which provide value creation and progressive dynamics of profitability and value; secondly, all intellectual assets have mainly intangible form and competence content, ie are considered in the system of productive qualities of the carrier / owner; thirdly, the productivity of intellectual assets of human potential provides current and future benefits for the carrier / owner and all levels of the environment in which he is involved in the status of economic activity and, at the same time, determines the rational use of the full range of qualities, abilities and other components of human potential. based on the natural dominant role of intelligence [11; 12].

The basis for the formation of intellectual assets is the developmentable share of human capital, which under the influence of investment in the external and internal environment is transformed into intellectual capital. In view of this, intellectual assets can rightly be recognized as an active factor of production in the post-industrial economy and the knowledge economy. Modern significant transformation processes that are common in the world economy occur under the influence and are accompanied by digitalization, which characterizes the transition of biological and physical systems to cyberbiological and cyberphysical, ie from the real world to the virtual world (online) [13].

At present, digitalization is global in nature and creates new requirements not only for individuals but also for businesses. It has already affected all spheres of human life: the emergence of the Internet of Things, robotics, artificial intelligence, eHealth and more. Particular attention should be paid to the changing business environment and business competitiveness due to new opportunities such as: automation of most everyday workflows, creating quality and attractive content, the ability to create digital goods, use of e-marketing and chatbots and more. That is, with the development of digitalization is the transformation of the socio-economic sphere of countries: changing the system of capital distribution, the functioning of business and the labor market, modernizing communications with the state and the provision of public services. And for the rapid and sustainable development of digitalization, it is necessary to provide all participants in this process with the following: improved access to goods and services via the Internet; creation of the necessary infrastructure to maintain appropriate conditions for the development of the digital economy; maximizing the potential of the digital economy [14]. It is impossible to achieve all of the above without developing the necessary skills and competencies, namely digital.

Interest in man and his knowledge has become especially acute in the context of the digital economy and the acceleration of the transition to the 4th industrial revolution, which, according to Klaus Schwab, will be fully manifested in 2025, when numerous large-scale changes in all spheres of human life due to unprecedented horizons. in the processing and storage of information and access to knowledge [15, p. 7]. The pace of change will be much faster than in previous periods, as digital, physical and biological systems are becoming increasingly interconnected in today's world. The reaction of the world community demonstrates the rapid perception of forecasts and current trends and the introduction of appropriate steps to promote and develop the infrastructure of the digital economy, involving the population in the process of digitalization. The spread of the digital economy confirms the growing share of intellectual activity in the value of social product and dependence on this level of national economy and forces the population to develop digital and other related skills, which are one of its main elements along with digital infrastructure and digital transformation projects.

In the digital economy, human potential at all levels of government should be given priority, especially its intellectual component, which is able to capitalize and ensure high added value, which will determine the future level of competitiveness at both micro and macro levels [4, p. 46].

In modern scientific circles, a single approach to the definition of the term "digital literacy / digital competence" has not yet been formed. Most scholars agree that digital competencies are a collection of all the knowledge, skills, abilities that are necessary for the confident and effective use and application of information and communication technologies for professional and everyday life. It should be noted that “competence in digital technology should be perceived not only as knowledge related to technical skills, but also as knowledge focused more on the cognitive, social and emotional aspects of work and life in the digital environment [16].

That is, digital competencies reflect the ability to understand communication tools, search for information and be critical of it, analyze and discuss with others through the use of new tools, technologies in the field of ICT. products, new ways of doing business, etc., which is possible only with the active digitalization of the economy. Thus, the problem of assessing the level of digitalization of the economy is of scientific and applied interest.

Currently, a number of indices and methodologies are used to assess the level of digitalization of the economy, the transformation of the digital economy and society, which to some extent more reveal the following: the index of development of information and communication technologies (ICT Development Index – IDI); index of digital economy and society (Digital Economy and Society Index – DESI); index of digital evolution (Digital Evolution Index – DEI); global digital competitiveness index (IMD World Digital Competiveness Index – WDCI); network availability index (Networked Readiness Index – NRI); index of digitalization of the economy

BCG (e-Intensity) [16]. Among these, one of the most popular is the index DESI (The Digital Economy and Society Index), which has a more social orientation and combines both economic and social indicators of society [17] and includes [18; 19]:

– Connectivity (internet access, 25%): measures access to fixed high-speed and ultra-fast broadband Internet access, including mobile Internet, affordable pricing policy;

– Human capital (Internet user skills and advanced skills, 25%): measures Internet use skills, skills that allow to participate in the digital society, consume, develop digital goods and services;

– Use of internet (Citizens' use of Internet services and online transactions, 15%): measuring the level of content consumption (news, music, video content, games, etc.), making purchases online;

– Integration of digital technology (business digitization and e-commerce, 20%): use of the Internet to reduce costs, greater interaction with customers, employees and business partners, modernization of business processes, use of new sources of income;

– Digital public services (e-government and e-health, 15%): measuring the level of business interaction with the public sector, simplification and improvement of public services for effective interaction / efficiency of citizens, business.

This index has an improved form of I-DESI and allows you to make appropriate comparative assessments not only for EU countries but also for other countries, including Canada, China, Israel, Turkey, Japan, Mexico, India and others.

The Ukrainian government is currently taking rapid steps to develop digitalization. Thus, in 2019, the Ministry of Digital Transformation of Ukraine was established, which in a short time has already introduced an educational platform for digital skills "Action: Digital Education" and facilitated a study by MLS Group on the level of digital skills based on the methodology used by the European Commission Index of Digital Economy and Society [20]: the methodology for calculating one of the indicators is an indicator of digital skills, the content of which has been meaningfully and linguistically adapted to Ukrainian realities. In the study, 1,800 people aged 18-70 were interviewed face-to-face. All digital skills were divided into four areas of competence: information skills, communication skills, problem solving skills, software skills.

In all four groups of skills there is an asymmetric development between the population of cities and villages, due to the uneven development of these areas. Although, the difference between the level of mastery of skills is not significant enough, and sometimes, even the level of mastery of skills (information skills) in villages exceeds the mastery of skills in cities, which is quite debatable (Table 5).

Thus, according to the results of the MLS Group survey, it was determined that 53% of the population of Ukraine is below the "middle level", and 15.1% of them do not have digital skills at all. People who do not have digital skills include mainly the older generation aged 60-70, the unemployed and those who do not have an Internet connection.

Table 5

Development digital skills in terms of terrain type, %

Skills	Skill level	Regional center	City	Village
Information skills	no skills	33,0	25,9	6,9
	basic	6,5	8,2	5,8
	above basic	80,7	70,9	72,1
Communication skills	no skills	13,4	20,2	23,8
	basic	5,3	5,1	6,4
	above basic	81,2	74,7	69,8
Problem solving skills	no skills	14,1	20,8	25,2
	basic	23,4	26,1	23,3
	above basic	62,5	53,1	51,5
Software skills	no skills	43,7	54,6	58,4
	basic	22,2	15,9	19,3
	above basic	34,1	29,5	22,3

Source: based on [20]

Today's sustainable economic growth is closely linked to digitalisation, which sets new demands on human resources and prioritizes intellectual assets. In such conditions, in order to increase digital literacy of the population and the level of digitalization of Ukraine's economy, it is necessary to prescribe at the legislative level the basic concepts and requirements for digital skills / competencies, pay significant attention to the implementation of digital skills development programs. which should be accompanied by the introduction of the necessary statistical indicators. In addition, it is important to improve and provide the population with the necessary conditions for the use of ICT in everyday life and in work processes: maximum dissemination and coverage of the Internet; raising the standard of living of households in order to more fully involve them in the use of more equipment (personal computers, laptops, tablets, etc.), etc.. At the state level, special attention should be paid to EU standards and strategies for digital development, classification of digital skills and approaches to their research and evaluation in Ukraine. Increasing investment in new technologies will open new opportunities for Ukraine: growth of socio-economic level; acceleration of workflow automation; raising the living standards of the population; increasing the number of jobs; improving and simplifying the provision of most services and access to them; improving the interaction between the state, the population and business representatives.

REFERENCES

1. Bradley K. Intellectual capital and the new wealth of nations II. *Business Strategy Review*. 1998. Vol 8. № 4. Pp. 33–45.

2. Брукинг Э. Интеллектуальный капитал. СПб : Питер, 2001. 288 с.

3. Леонтьев Б. Б. Цена интеллекта. Интеллектуальный капитал в российском би знесе : Оценка, ориентирование, моделирование, защита прав. Москва : Акционер, 2002. 196 с.

4. Карпенко А.В. Розвиток інтелектуальних активів людського потенціалу: теорія та практика : монографія. Запоріжжя: ФОП В. В. Мокшанов, 2018. 510 с.

5. Бланк И. А. Управление активами. К. : Ника-Центр, 2000. 720 с.

6. Ібрагімов Е. Е. Моделювання впливу інтелектуальних активів на ефективність корпоративного управління з орієнтацією на знання. Формування ринкових відносин в Україні. 2012. № 5/1 (132). С. 119–124. URL: http://nbuv.gov.ua/UJRN/frvu_2012_5(1)__28

7. Мартиненко М. В. Кількісний підхід до визначення впливу інтелектуальних активів на результати інноваційної діяльності підприємств. Актуальні проблеми економіки. – 2014. № 6. С. 520–529.

8. Смит А. Исследование о природе и причинах богатства народов / пер. с англ. В. С. Афанасьев. М. : Эксмо, 2007. 957 с.

9. Илышева Н. Н., Кузубов С. А. Интеллектуальные активы – главный ресурс посткризисной экономики. Национальные интересы: приоритеты и безопасность. 2009. № 7 (40). С. 9–15.

10. Марченко О. С., Ярмак О. В. Національна інноваційна система як інтегратор знань : монографія. Харків : ІНЖЕК, 2012. 242 с.

10. Погорецький П. П., Нищик Р. А., Фесенко О. М. Проблеми комерціалізації наукових розробок та інноваційної діяльності в Україні. *Вісник Національного технічного університету «ХПІ». Технічний прогрес та ефективність виробництва.* Харків, 2013. № 44. С. 120–124.

11. Карпенко А. В. Інтелектуальні активи: етимологія поняття та місце в національній інноваційній системі. *Економіка і організація управління: збірник наукових праць*. 2017. № 4 (28). С. 65–80.

12. Карпенко А. В. Интеллектуальные активы человеческого потенциала. *Корпоративные стратегические коммуникации: новые тренды в профессиональной деятельности:* материалы II Международной научно-практической конференции (г. Минск, 22–23 февраля 2018 г.) / Белорус. гос. ун-т ; редкол.: И. В. Сидорская (отв. ред.) [и др.]. Минск : БГУ, 2018. С. 88–90.

13. Економічна стратегія України 2030. URL: https://strategy.uifuture.org

14. Проблеми та перспективи гармонізації цифрового ринку України з ринками ЄС та країн СхП: аналітичний звіт. URL: https://cid.center/wp-content/uploads/2019/02.pdf

15. Schwab K. The Fourth Industrial Revolution. Geneva: World Economic Forum, 2016. 172 p.

16. Овладение цифровыми знаниями для использования существующих и новых технологий с особым акцентом на гендерной и молодежной проблематике: доклад Генерального секретаря. Комиссия по науке и технике в целях развития. Двадцать первая сессия, Женева, 14–18 мая 2018 г. Организация Объединенных Наций. URL: https://unctad.org/meetings/en/ SessionalDocuments/ecn162018d1_ru.pdf

17. Піжук О. І. Сучасні методологічні підходи до оцінювання рівня цифрової трансформації економіки. *Бізнес Інформ*. 2019. №7. С. 39-47

17. Ткалич Т. А. Оценка и прогнозирование показателей результативности цифровой экономики методом ABC-анализа. *Економічна наука. Економіка та держава,* 2017. № 3. С. 16-20

18. Digital Economy and Society Index (DESI) 2019: Questions and Answers.

URL: https://ec.europa.eu/commission/presscorner/detail/en/MEMO_19_2933
19. Mateus A. DESI / I-DESI Digital Economy and Society Index. European Commission DG Connect, 2016. URL: https://unctad.org/meetings/en/Presentation/dtl_eweek2016_AMateus_en.pdf
20. Цифрова грамотність населення України. URL: https://fr.slideshare.net/mResearcher/ss-210277156

2.4. Benefits of green jobs for employment and employees

Nataliia Bieliaieva
PhD (in Economics), Associate Professor,
Associate Professor of Department of Management
Kyiv National University of Trade and Economics
E-mail: n.bieliaieva@knute.edu.ua
ORCID ID ORCID ID: 0000-0001-8833-1493

Green economy is one of the key targets of the 2030 Agenda for Sustainable Development. Sustainability and green jobs are a growing industry and advanced countries working in that direction very rapidly. Striving to provide maximum level of energy efficiency of production, reduce the level of resources spending and minimize the negative impact, green jobs are one of the fastest growing and changing segments of the world economy, however this category has emerged relatively recently as an answer for a green economy arising. Opportunities to create millions of green jobs are an answer and a result of transition to a decarbonised economy, which is environmentally friendly, and the circular economy, which involves reusing, repairing or recycling, increasing sustainable manufacturing and consumption. However, implementation of circular economy model is pressed by a policy, technology and public involvement issues so it's not so easy to realise it; therefore, niche growth might come from developing distinctive waste management-driven green jobs, formalizing informal waste pickers and by focusing in education and training of informal worker [1]. Green companies strive to support the sustainable development of their country's economy and its community by producing products with minimal damage, introducing environmental values and principles among their employees and stakeholders, making partnerships with charities and sponsoring community events and initiatives.

In a time of a green economy introducing, green jobs were connected only with biodiversity and the environment protection and in a case of provision decent and safe working conditions. Recently, the meaning of this concept has expanded to include jobs that are striving for more efficient use of resources, reduction of emissions in the green sectors, and professions that play a central role in the process of economy greening. Nowadays green jobs are the availability of new employment opportunities within a huge amount of new visualisation of professions - from managers and scientists to technicians and farmers.

Green jobs (or otherwise, eco or environmental jobs, green-collared jobs, sustainability jobs) are presented like – "green jobs: good for you, good for the environment and good for the economy" as each side has some benefits. Talking about green jobs means presenting jobs aimed directly at protecting the environment or which connected with minimization of humans' impact on the planet existence [1]. Green jobs connected with any jobs that have a direct and positive impact on the planet, that influence on formation of a low carbon economy of the future, as they strive for unemployment level reducing and prevention of the environment degradation. The economy should urgently be redesigned so that resources aren't wasted.

Identification and green grading jobs diversifying energy sources, sustainable development, securing energy, removing environmental and health problems would help to managers and policy makers for identifying and providing executive solutions and identifying multifaceted priorities for green management [2].

According to the International Labour Organization (ILO) [3], this type of job: limits greenhouse gas emissions; protects and restores ecosystems; improves energy and raw materials efficiency; minimizes waste and pollution; contributes to adaptation to climate change. To protect our future, every job must be a 'green job'. This means that every worker must have a good understanding of climate change, the impact their work has on the environment, and how to reduce that impact. But in real it's really difficult to implement into the life. Green jobs are also connected with ecological employment that is a new type of employment associated with the elimination of accumulated damage, disturbed land, processing of solid waste, the introduction of environmental innovations, etc.

The United Nations Environment Program (UNEP), the International Labour Organization (ILO), the International Organization of Employers (IOE) and the International Trade Union Confederation (ITUC) are jointly implementing the Green Jobs campaign. This campaign supports the concerted efforts of governments, employers and trade unions to develop and implement, in a climate facing world, environmentally sustainable and coherent policies and effective programs to create green jobs and promote decent work for everyone. Green jobs also become popular due to principles of the green recovery that is the part of the main political projects in the European Union. The European Union (EU) has now announced the European Green Deal. Europe has already linked its future with green jobs and technology. Twice as many people work in this area as in the automotive industry. Indeed, it is thanks to this approach that the consumption of electricity, water, raw materials is reduced, the emission of greenhouse gases and production waste is reduced, the ecosystem and biodiversity are preserved.

However, other countries also work in this direction. In Spain, for example, the Government has proposed a Climate Change and Energy Transition Law that aims to achieve climate neutrality by 2050 and incorporates ambitious intermediate targets for emissions, renewables and improved energy efficiency [4]. The UK industry will also receive £350m investment to cut carbon emissions in sectors such as transport and construction. By comparison, France is planning to invest one third of its €100bn (£90bn) post-Covid economic stimulus on greening the economy – more than any other big EU country – but critics insist that even this falls short of what is necessary for a step change. Germany's €130bn recovery budget focuses on climate-friendly industries and aims to support green infrastructure and technologies with at least €40bn spending in this area. Investing in forest conservation and restoration could increase formal employment alone by 20% by 2050. For transport, improving energy efficiency in all modes of transport and switching from private transport to public or non-road transport would further increase employment by about 10%. Finally, investments in energy efficiency improvements in buildings and structures could create only in Europe and the USA 2 - 3.5 million additional work places. For now, 19.4% of US workers could currently be part of the green economy in a broad sense, although a large proportion of green employment would be 'indirectly' green, comprising existing jobs that are expected to be in high demand due to greening, but do not require significant changes in tasks, skills, or knowledge [5]. And Denmark, one of the greenest countries in the world, has created 300,000 green jobs over the past 2 years. Mainly in factories producing wood windows, insulation materials, thermostats and pumps that reduce energy consumption. For example, within the framework of the Smart City Fied project, such residents of the Spanish city of Laguna de Duero were involved in refurbishing buildings and increasing their energy efficiency. After completing a simple training course, they quickly mastered the installation of solar panels on the roofs of houses, and started servicing charging stations for electric cars.

At the same time, the potential for "green" investment and the use of these instruments on a much larger scale is still limited. Green projects could receive much more funding if investors had more reliable information about the projects and their participants. Potential investors are deterred by the lack or fragmentation of information on how proposed projects will affect (or may affect) the state of the environment, what is the cost-benefit ratio, given that such projects are usually long-term. The initiative to create green jobs also comes from small businesses. The Finnish firm Paptic, employing only 10 people, has developed an environmentally friendly technology for the production of easily recyclable packaging paper based on cellulose and bioplastic, replacing conventional polyethylene.

Even for now, for example, in Germany, the renewable power generation industry is experiencing a shortage of skilled workers. In fact, a shortage of skilled workers is felt in almost all energy sub-sectors, especially hydropower and the energy use of biogas and biomass. An equally acute shortage of personnel is observed in mechanical engineering for the needs of renewable energy; there is a particularly shortage of engineers, operators and maintenance specialists, as well as plant managers. And in China workers at wind firms had higher average annual incomes and better job security, experienced better occupational conditions and enjoyed a higher level of workplace protection measures than their counterparts in conventional power plants. Some 77 per cent of Chinese wind power workers surveyed considered their work environment "very good", compared with just 18 per cent in large thermal power plants and 13 per cent in small plants.

However, the nature of green economy investments is peculiar, because the need of government intervention to create new market opportunities could produce a lower return relative to other innovations [6]. Anyway, bureaucracy and lack of infrastructural investments are revealed as barriers to the creation of green jobs and local green businesses development [7]. Labour market policies should focus on preserving employment rather than individual jobs. It should provide an opportunity for employees and enterprises to quickly adapt to changes, associated with the transition to a green economy, including the use of new emerging opportunities. Helping workers move from jobs in shrinking sectors to jobs in growing sectors, it can also help ensure a fair distribution of adjustment costs, caused by such a transition. Environmentally sustainable products and services will often require higher levels of skills. Higher environmental performance and competence requirements in firms and sectors may also call for more stable and formal employment and enterprises. Green growth sectors and occupations may offer more or less equal opportunity to women and men or groups of jobseekers. Similarly, these jobs may provide more or less opportunity to exercise the right to organize and bargain collectively. So new skills will be required, and this will require appropriate actions in education policy. While many existing skills will remain relevant, mismatches and gaps can still occur. Training and retraining programs should become a key component of labour market policies. However, disciplines and practices should focus on the formation of future professionals' competencies needed to work in line ministries and authorities at various levels, or to start and run a "green" business (green-start-ups), developing and implementing environmental modernization programs and implementing environmental management systems. At the same time, the educational component should be systematic, including the level of both preschool educational institutions and the general education system. In Brazil, for example, 7,000 workers are retrained each year. In China, 276,000 workers underwent vocational retraining in 2002. In Singapore in 2007, approximately 67500 workers confirmed the acquisition of new professional skills and received the appropriate certificates

Based on international experience, it can be argued that the transition to a green economy transforms the qualitative characteristics of employment. Thus, according to studies by foreign scientists, green workplaces require workers to have a higher level of education, work experience and highly qualified professional training in comparison with those employed in non-green workplaces.

At the enterprise level, green jobs can produce goods or provide services that benefit the environment, for example green buildings or clean transportation. However, these green outputs (products and services) are not always based on green production processes and technologies. Therefore, green jobs can also be distinguished by their contribution to more environmentally friendly processes. For example, green jobs can reduce water consumption or improve recycling systems. The energy efficiency industry grew 1.7 times as fast as the national workforce 2016–2020. Local employment, better health, job opportunities, job creation, consumer choice, improvement of life standard, social bonds creation, income development, demographic impacts, social bonds creation, and community development can be achieved by the proper usage of renewable energy system [8]. Also, the over-exploitation of NTFPs, which could be attributed to considerable economic income, poor resource management, and lack of good community leadership, is a common problem [9]. Environmental policy both directly and indirectly creates new jobs, the so-called green jobs. Environmental policy is a set of objectives put in place for the protection of natural resources including water, air, soil, food, and other renewable resources. In addition, it has a considerable impact on the labour market and the income of employees in the environmental and forestry sectors [10]. It is estimated that increasing energy efficiency by 1% per year over ten years will help create and maintain 200,000 new jobs in the European Union during this period. Yet, green jobs defined through production processes do not necessarily produce environmental goods or services [3].

The concept of a “green” workplace is not absolute, as there are different “shades” of green, within which there are thresholds on which the degree of environmental health depends. In the process of modern society striving for a "green" economy, this concept is constantly evolving. Initially, only those jobs related to the protection of biodiversity and the environment were considered “green”. More recently, the concept has expanded to include jobs that promote more efficient use of resources and reduce emissions in green sectors, as well as occupations that play a central role in greening industries. So, in general, green jobs vary in ‘greenness', with very few jobs only consisting of green tasks, suggesting that the term ‘green’ should be considered a continuum rather than a binary characteristic. It can be defined 3 subcategories of green jobs according to the effect that greening will have on the tasks, skills, and knowledge required for the job [5].

1) Green Increased Demand (Green ID) are existing jobs that are expected to be in high demand due to greening, but do not require significant changes in tasks, skills, or knowledge. These jobs are considered as indirectly green because they support green economic activity, but do not involve any green tasks.

2) Green Enhanced Skills (Green ES) are existing jobs that require significant changes in tasks, skills, and knowledge as a result of greening.

3) Green New and Emerging (Green NE) are unique jobs (as defined by worker requirements) created to meet the new needs of the green economy.

Anyway, green collar workers have a distinct socio-demographic and occupational profile, and this workforce deserves active surveillance to protect its workers' safety [11]. However, there exist some paradoxes and nuances:

- jobs at the enterprise that produces environmental goods / services (green products), but the production process and technology are not always environmentally friendly;
- jobs at the enterprise that uses environmentally friendly technologies and processes (green technologies, processes), but its products / services are not necessarily environmentally friendly;
- from the point of view of the International Labour Organization, in any case, jobs can be considered green if they also meet the criteria of decent work.

As our population becomes more environmentally aware, a host of job opportunities in the sustainability and green jobs industry are becoming available. Green jobs cover a wide range of professional activities, crafts and specialties. Some of them represent completely new types of work, but most are traditional professions, although with small changes in the essence of the content and attitude to the work itself. This applies to both direct and indirect green jobs created in industry and related to supply. We can find green jobs in almost all industries: Renewable Energy, Environmental Protection, Recycling, Sustainable Transportation, Technology, Governmental and Regulatory Administration, Business and Administration. More accurate and narrow are: work with environmentally friendly energy systems (solar, wind, water sources); harmless waste disposal; creation of environmentally friendly agricultural infrastructure; renewable energy sources. It covers a wide variety of job types including – alternative energy jobs, biofuel jobs, biomass jobs, carbon jobs, conservation jobs, ecology jobs, energy efficiency jobs, environmental jobs, environment jobs, green jobs, hydro jobs, hydropower jobs, marine jobs, offshore wind jobs, renewable energy jobs, solar jobs, sustainability jobs, tidal jobs, waste jobs, wastewater jobs, water jobs and wind jobs. Table 6 shows examples of green jobs positions in different industries.

Table 6

Examples of green jobs positions

№	Green jobs positions	Responsibilities
1	Solar panel installation technician	Installs, maintains and repairs solar panels.
2	Drone engineer	Obtains data about difficult and expensive-to-access locations. Very useful for environmental management.
3	Nuclear Engineer	Responsible for numerous tasks depending on what kind of industry they enter. Many are involved in designing the advanced machinery used to run nuclear power plants and complex medical equipment.
4	Operator in a renewable energy plant	Working from the operations centre, the operator will be responsible for plant maintenance and optimisation.
5	Sustainability specialists	Practical, devising ways of saving money and suggesting schemes to move the organization forward with its green credentials.
6	Recycling plant technician	Responsible for separating or reprocessing the materials arriving at the plant.
7	Environmental Public Relations Specialist	Put together PR campaigns and implement pollution education programs in their communities.
8	Environmental scientist	Finds solutions to environmental problems caused by contaminating substances.
9	Smart network manager	Managing these IT networks will help optimise the production and distribution of electricity.
10	Biofuel Production Operator	Working at factory sites to ensure smooth running and quality assurance
11	Agricultural Scientist	They study commercial plants, animals and cultivation techniques in order to improve the productivity and sustainability of farms and agricultural industries
12	Electric Car Engineer	Use science and maths to design and develop electric automobile technology. They then undertake evaluations with respect to measure the safety, efficiency, cost, reliability, and safety of these aforementioned designs.
13	Green Building Designers	Design buildings that in their design, construction or operation, reduce or eliminate negative impacts, and can create positive impacts, on our climate and natural environment
14	Wind Energy Technician	Wind technicians install, inspect, maintain, operate and repair wind turbines.
15	Wetland specialist	Study the conditions that allow animals and unique plant life to thrive in wetlands and the factors that affect wetland health.
16	Watershed Manager	Responsible for the management of all water supplies – not just sewage and waste water, but effective drainage, flood mitigation and other water rights and ecology.

Source: created by the author on the base of [4; 12]

Green jobs can be created in literally every office if you get it right. To save energy, it is necessary not only to use energy-saving lamps, but also to properly plan windows in buildings. It is necessary to use more electronic media, rather than paper, etc. At the same time, the employment conditions in sustainability careers and other green jobs vary considerably from position to position. For example, a Director of Responsibility would work in an office, overseeing a corporation's approaches to the environment and energy consumption. On the other hand, a soil and plant scientist may spend a great deal of time out in the field, enduring adverse weather conditions as they monitor soil PH levels and discover measures to prevent soil pollution. Also, it should be taken into account than even with abundant renewable resources and well performing technologies measured using levelized cost of electricity and expected internal rate of return, investment on renewable electricity generation is quite low, so in some countries managements don’t accept importance of green direction in general [13]. In countries where government funding, dependent on tax revenues and the government's ability to leverage in capital markets, is limited, subsidy and tax policy reforms can be used to increase green investment.

Senior sustainability and green job roles are similar to other management roles, with one key difference - these experienced professionals place environmentally sustainable solutions at the core of their business strategy. Careers do vary widely depending on the job, however most senior sustainability professionals will be asked to perform the following tasks at some point in their career:

- Design outcome measurements for green initiatives.
- Understand the impact of each sustainability program or measure in order to accurately strategize.
- Work with compliance professionals to meet technical guidelines.
- Provide leadership and strategy.
- Vet research directions prior to employee pursuit.
- Provide expert environmental advice to assist clients' planning efforts.
- Define the scope of a project and its benchmarks.
- Track projects schedules, costs and deliverable items.
- Participate in public meetings and hearings.
- Respond to public comments.
- Evaluate employee and contractor performance.
- Provision project, material and human resources.

In general, there are two main strategies for creating green jobs:

1. The first includes "greening" of existing enterprises, jobs through the introduction of green technologies, processes that reduce environmental risks, increase resource efficiency, minimize emissions and pollution.

2. The second is the creation of enterprises, jobs that will produce green goods / services to measure, prevent, reduce or eliminate damage to the environment.

The most common change in greening will be the redefinition of many jobs. Were cleaners and service personnel - became service and logistics managers, were electricians - became information technology experts, were masons - became architects, were loan clerks - became investment managers: people in the workplace at all levels will see how the content of work changes, its implementation and requirements for professional skills. The global eco-trend, which covers all spheres of modern life, did not go unnoticed by the working environment of office-type organizations, embodied in the concept of "green office", which has already become the hallmark of many leading companies and is gaining popularity. A green office is an environmentally responsible office that makes the most efficient use of the natural resources necessary for its work, constantly taking care to reduce its own negative impact on the environment (reduction of consumption of water, energy, other resources); refinement the amount of waste when working in offices; replacement (recycle) - purchase goods and services that minimize environmental impact, promote more efficient use of transport for personal and business purposes, etc.

An important element of this definition is that jobs should not only be green, but also comply with the principles of decent work, that is, they are jobs characterized by productive employment, the provision of adequate income and social protection, respect for workers' rights and giving them the right to vote in adoption, decisions affecting their lives. Contrary to expectations, lower-level green employees engage substantially in job crafting as a form of identity work despite their limited discretion. In addition, lower-level green employees make use of identity work strategies that uphold rather than diminish perceived misalignment between their green identities and their job context [14]. In accordance to all employees, it is also for the best to implement a green design as a workplace innovation that boosts the stress resilience that leads to the decreased emotional exhaustion and increased job satisfaction [15]. To understand it deeper, in Table 7 it is presented information what enterprises should take into account in creation green job at theirs structure/.

Table 7

Criteria for a green workplace at the enterprise

Criteria for a green workplace	Essence of criteria	Quantitative and qualitative criterion characteristics
Economic	Decent wages, high level of labour productivity, low material consumption	Quantification of the criterion based on existing standards, best available technologies
Social	Observance of labour rights of employees, availability of social guarantees	Qualitative assessment (observance / non-observance of workers' rights), presence / absence of social and environmental guarantees, etc.
Technical and technological	The use of modern high-tech equipment, availability of safe working conditions, investment in fixed assets	Quantitative indicators (application of the best available technologies, financing of environmental modernization production)
Environmental	Reducing negative impact on the environment	Quantitative and qualitative indicators characterizing the quality of the environment (MPC indicators of the working area, etc.)

Source: created by the author on the base of [2; 8; 12]

So, to summarize the benefits of a green economy and introduction of green jobs for employment and employees, there would be a pretty wide list:

- lead to endless opportunities to create new professions, which provide mainly the highest level of qualification, in particular in the field of business services, in small and medium enterprises (income level). New jobs will be created in the course of changes in the energy sector: for example, the mass transition to electric vehicles and improving the energy efficiency of buildings. As a result, the demand for specialists will increase, for example, in the purification of air, water and soil, as well as protection against extreme weather events.;

- directly and indirectly increase the number and share of jobs with the most comfortable and healthy working conditions (long and healthy life);
- new, "fashionable" professions are not burdened with a history of gender stereotypes and segregation, so they help to overcome existing gender barriers, provide more equal opportunities for career advancement (social inclusion);
- stimulate the development of science, technology, engineering and mathematics (education and knowledge);
- encourage the practical implementation of the concept of lifelong learning, regular updating and expansion of knowledge, maximizing adaptability to change and professional mobility;
- strengthen stability of employment, in particular, the influence of seasonality will decrease;
- give a possibility to transfer certain types of employment from the informal to the formal employment sector (social inclusion);
- gains in eco-efficiency and access to new and growing markets can lead to higher profits, incomes and wages. Conversely, additional costs which cannot be compensated may depress earnings. These impacts are a result of how the shifts in employment affect primary incomes, most importantly the levels of wages among workers and incomes among the self-employed, as well as the redistribution of incomes through taxation, social protection and prices.

As an example of some additional benefits, it’s needed to analyse some specific fields of activity. Greening agriculture and especially smallholder farms will help reduce poverty and increase investment in natural capital, on which the poor depend. Greening the small farm sector through the promotion and dissemination of sustainable agriculture can be the most effective way to increase the availability of food available to the poor people, carbon storage and the availability of growing international markets for green products. The introduction of green jobs in small enterprises and especially in the field of agriculture should be influenced by the state as a guarantor of the implementation of the support system for agriculture, especially in certain agricultural areas, in particular, on the legal regulation of this process. Creation of a green jobs in different fields of activity requires different peculiarities (Table 8).

Anyway, with the introduction of green jobs at enterprises, new regulations are needed that regulate decent working conditions, namely fair wages, improving occupational safety, new guarantees in the event of disability, and others. At the same time, updating knowledge on ensuring safe and decent working conditions in the transition to a green economy should primarily concern business leaders (owners, top-managers), because they are in charge of landscaping jobs. The significance of green jobs goes beyond the creation of employment. They are not merely the passive outcome of redirecting investments into greening the economy. Rather, competent enterprises with skilled, motivated and enabled workers are critical for reaping the positive environmental and economic outcomes from the investments.

Table 8

Peculiarities of green jobs creation in a different fields of activity

Field of activity	Ways to create green jobs
Agricultural sector	introduction of organic farming methods, development of rural infrastructure (roads, access to water and modern energy sources), green tourism
Food	introduction of eco-labelling; development of organic agriculture
Forest sector	reforestation and afforestation activities, creation of green zones in urban agglomerations, landscape projects, soil reclamation
Fisheries sector	fish farming, fish and seafood processing, application of aquaculture technologies to reduce water pollution, recreational programs
Energy sector	use of renewable energy sources (solar, wind, bioenergy)
Industrial sector	introduction of resource-saving technologies and processes, focus on closed cycle production (incl. recycling), use of waste instead of primary raw materials, modification / repair of finished products
Social sector	adaptation of the economy and population to climate change; increasing the energy efficiency of housing; formation of a system of sustainable consumption
Recycling	collection, sorting and recycling, recycling of consumer electronics (computers, mobile phones and other devices - so-called e-waste)
Construction	renovation of existing and construction of new buildings using modern, environmentally friendly technologies, processes and materials
Transport	development of public transport, use of alternative fuels and transport, improvement of infrastructure
Financial sector	formation of the carbon market; "green" procurement; "green" electricity tariffs
Services	eco-audit, consulting, design, research and development; sale, installation and maintenance of eco-goods

Source: created by the author on the base of [3; 5]

Green jobs are central to sustainable development and respond to the global challenges of environmental protection, economic development and social inclusion [3]. An increasing number of national governments are developing their own definitions of green jobs for use in statistical data collection and policy decision-making. However, the very movement for the creation of "green" jobs is most common in countries that put working conditions first - the United States, Canada, Germany. Either way, for example, the UK government wants to create more of them, going from 410,000 now to two million of these jobs by 2030, as part of its plans for an economy with zero fossil fuel emissions. California has a special training program for specialists in the installation and maintenance of alternative energy sources – wind and water mills, solar panels, etc. Anyway, not only do green jobs present a golden opportunity to reverse unemployment, they're also basic common sense. Moreover, green jobs are a solution for young, unemployed people who not only can find employment but can become entrepreneurs in this sector of the economy [16]. Right now, young people are being taught and given careers advice on jobs that may not even exist in 10 years' time.

The green economy today costs as much as the fossil fuel sector, but offers more significant and “safe” investment opportunities. Today, the green economy accounts for 6% of the world stock market (about $ 4 trillion), which "works" in projects of "clean" energy, energy efficiency, water supply, waste management and more. If the sustainable economy maintains its current course and development trends, as well as about $ 90 trillion of "green" investments are invested, then in 2030 it will form about 10% of the world market value.

By 2030, the projected demand for energy and water will increase by 50% and 40% respectively. To meet needs new jobs will be created in areas such as manufacturing alternative energy, new technologies, new product development, recycling and use secondary resources. Millions of people employed in the field of traditional energy, and the industry as a whole will succumb rapid reorganization. However, creation of green jobs is not as fast as it seems at first view, especially in non-advanced countries. New production technologies with the reduction of manual labour are being introduced, methods of individual protection of workers are being improved, but these processes are still being tested. New jobs need to be modernized and made available to many citizens. First of all, new technologies require specially trained workers, so government and enterprises have a duty to train them, which also requires the development of a special regulation on the training of professionals for green jobs.

The main trends in green employment are the formation of new areas of economic activity related to environmental protection, rational use of natural and energy resources, reduction of greenhouse gas emissions, introduction of eco-technologies, processing and disposal of waste, production of environmentally friendly products. in the field of environmental protection, which creates conditions and preconditions for green employment and the creation of new green jobs. The formation of an environmentally oriented and low-carbon economy in modern conditions in many countries is a priority and is associated with the advanced development of new types of employment in the labour market and the creation of new jobs.

REFERENCES

1. Sharma, H.B., Vanapalli, K.R., Samal, B., (...), Dubey, B.K., Bhattacharya, J. (2021) Circular economy approach in solid waste management system to achieve UN-SDGs: Solutions for post-COVID recovery. *Science of the Total Environment*. DOI: https://doi.org/10.1016/j.scitotenv.2021.149605
2. Razikordmahaleh, L., Larijani, M. (2020) Identification and green grading of jobs in the renewable energy field of the biomass: A grounded theory study. *Iran Occupational Health,* 16(6), c. 40-52. URL: http://ioh.iums.ac.ir/article-1-2211-en.html
3. Green jobs / *International Labour Organization* (ILO): official website. URL: https://www.ilo.org/global/topics/green-jobs/lang--en/index.htm
4. Green jobs: good for you, for the environment and for the economy / *Iberdrola*: official website. URL: https://www.iberdrola.com/environment/what-are-green-jobs
5. Bowen, A., Kuralbayeva, K., Tipoe, E.L. (2018) Characterising green employment: The impacts of 'greening' on workforce composition. *Energy Economics.* 72, c. 263-275. DOI: https://doi.org/10.1016/j.eneco.2018.03.015

6. Aldieri, L., Vinci, C.P. (2018) Green economy and sustainable development: The economic impact of innovation on employment. *Sustainability* (Switzerland). 10(10), 3541. DOI: https://doi.org/10.3390/su10103541
7. Battaglia, M., Cerrini, E., Annesi, N. (2018) Can environmental agreements represent an opportunity for green jobs? Evidence from two Italian experiences. *Journal of Cleaner Production*. 175, c. 257-266. DOI: https://doi.org/10.1016/j.jclepro.2017.12.086.
8. Mahesh Kumar (2020) Social, Economic, and Environmental Impacts of Renewable Energy Resources, Wind Solar Hybrid Renewable Energy System, Kenneth Eloghene Okedu, Ahmed Tahour and Abdel Ghani Aissaou, *IntechOpen*, DOI: 10.5772/intechopen.89494
9. Zhu, L., Lo, K. (2021). Non-timber forest products as livelihood restoration in forest conservation: A restorative justice approach. *Trees, Forests and People*. DOI: https://doi.org/10.1016/j.tfp.2021.100130
10. Maitah, M., Toth, D., Smutka, L., Maitah, K., Jarolínová, V. (2020). Income differentiation as a factor of unsustainability in forestry. *Sustainability* (Switzerland) 12(11),4749. doi:10.3390/su12114749
11. McClure, L.A., LeBlanc, W.G., Fernandez, C.A., (...), Moore, K.J., Caban-Martinez, A.J. (2017) Green collar workers: An emerging workforce in the environmental sector. *Journal of Occupational and Environmental Medicine*, 59(5), c. 440-445. doi: 10.1097/JOM.0000000000000986
12. Sustainability Careers & Green Jobs / *Environmental Science*: official website. URL: /https://www.environmentalscience.org/careers/sustainability-and-green-jobs
13. Osiolo, H.H. (2021) Impact of cost, returns and investments: Towards renewable energy generation in Sub-SaharanAfrica. *Renewable Energy*, 180, c. 756-772. DOI: https://doi.org/10.1016/j.renene.2021.08.082
14. Blazejewski, S., Dittmer, F., Buhl, A., Barth, A.S., Herbes, C. (2020) “That is Not What I Live For”: How Lower-Level Green Employees Cope with Identity Tensions at Work. *Sustainability* (Switzerland), 12(14),5778, c. 1-22. doi: 10.3390/su12145778
15. Han, H., Ariza-Montes, A., Giorgi, G., Lee, S. (2020) Utilizing green design as workplace innovation to relieve service employee stress in the luxury hotel sector. *International Journal of Environmental Research and Public Health*, 17(12),4527, c. 1-12. doi: 10.3390/ijerph17124527
16. Sulich, A., Zema, T. (2018) Green jobs, a new measure of public management and sustainable development. *European Journal of Environmental Sciences.* 8(1), p. 69-75. DOI: https://doi.org/10.14712/23361964.2018.10

III. EDUCATION FOR SUSTAINABLE DEVELOPMENT

3.1. Online education for sustainable development

Marta Dmytryshyn
Ph.D. (economic)
Associate professor in the Department of Management and Administration
Ivano-Frankivsk Educational and Scientific Institute of Management
West Ukrainian National University
E-mail: m.dmytrsyhyn@wunu.edu.ua
ORCID ID 0000-0002-0609-9764

Tetyana Goran
Ph.D. (history)
Senior lecturer in the Department of International Economics, Marketing and Management
Ivano-Frankivsk Educational and Scientific Institute of Management
West Ukrainian National University
E-mail: t.goran@wunu.edu.ua
ORCID ID 0000-0002-6618-8769

The leading idea of the world's socio-economic development in the XXI century is a strategy for sustainable development. It should be noted that the sustainable development strategy is not a product of the modern century, as its central ideas were formulated in the second half of the XX century. The main reason for the transition to sustainable development was the global problems of humanity caused by consumer attitudes to our planet. The table gives a brief history of the sustainable development idea (Table 9). Today, sustainable development is the model that will help achieve balance in human existence and overcome the crisis caused by human economic activity. It is, in fact, an ideal model of the third millennium, which should displace the extensive model of development.

The modern human is the newest element of the biosphere of the planet "Earth." According to scientists at the University of Leicester, humans changed the biosphere and created the technosphere with 30 trillion tonnes (Technosphere Weighs 30 Trillion Tons, 2017). V. Vernadskyy, who in 1934 defined the biosphere, said that humans managed to change the planet in such a short time thanks to intelligence. However, creating comfortable conditions should not be forgotten to maintain balance in the biosphere. Therefore, all need not be selfish but ecological users of nature. The Stockholm Center for Sustainable Development defines sustainability as the ability to accept change while continuing to develop. We can distinguish three main components of sustainability: persistence, adaptability, transformation. If we talk about the transformation of human society, then, above all, we mean new ways and opportunities according to the modern planet's development for human well-being. Sustainable vision begins with the realization that man and nature are integral and together create a socio-ecological system.

Table 9

The main stages of sustainable development idea forming

Date	Event	Value
1972	United Nations Environment Programme, UNEP	Promoting international cooperation in solving environmental problems.
1980	Global Health Strategy	The English term "sustainable development" has appeared for the first time.
1992	United Nations Conference on Environment and Development	The "Program 21" was adopted the intensification of the world community development in the direction of its sustainable development
1997	Conference in Kyoto	The Kyoto Protocol was signed for the greenhouse gas emissions limitation
2002	UN World Summit on Sustainable Development	Sustainable development is identified as one of the central international cooperation issues; the adoption of the practical measures necessary to address many pressing global issues has been ensured problems
2010	UN General Assembly meeting on the Millennium Development Goals implementation	Global partnership is identified as one of the most effective methods of ensuring sustainable development

Source: (developed by the authors based on Longyu Shi, Linwei Han, Fengmei Yang and Lijie Gao (2019*)*

Stockholm Center for Sustainable Development professors have developed 7 fundamental principles of sustainable thinking: maintaining diversity; managing relationships; working with nature, not against it; accelerating feedback; developing social capital; encouraging innovation; implementing a multicenter management system.

There is no reasonable alternative to sustainable development and the whole world community is taking certain steps to move to a new strategy for its progress in the XXI century. In September 2015, the UN Summit in New York adopted 17 Sustainable Development Goals, which by 2030 should ensure the improvement of our planet. In total, the goals have 169 tasks (86 tasks in the Ukrainian version). The "green" economy will not be interesting for those fighting for their survival. The global sustainable development strategy is based on each country's available resources and capabilities3 separately. 17 sustainable development goals can be divided into three levels: economic (8, 9, 10, 12 goals), social (1, 11, 16, 7, 3, 4, 5, 2 goals) and ecological (15, 14, 6, 13 goals). The main goal is 17 - partnership for sustainable development. There is a great human need for collective peaceful planetary cooperation in all spheres of human life. The purpose of such cooperation is the prosperity of our society and the biosphere. In 10 years, we will have 9 billion people, and then the question arises - how will we feed and ensure a decent life for our planet? (Sustainable Development GOALS).

According to UNESCO, globally, at least 773 million youth and adults still cannot read and write, and 250 million children fail to acquire basic literacy skills.

These results excluding low-literate and low-skilled youth and adults from full participation in their communities and societies (Literacy, 2021). In this context, we are interested in the 4th goal, which provides quality education. However, it is crucial to encourage lifelong learning. Moreover, mega-trends are shaping our future and education: digitalization, automation, a transformation of social institutions, demographic shifts, a societal transition towards sustainability. Today we live in a world that Americans call VUCA (volatile, uncertain, complex, ambiguous) (VUCA world). This term comes from the military Cold War vocabulary but is actively used in economics, business, and socio-political analysis in the XXI century. Significant acceleration of life and technological changes have a great impact on our way of life. Likewise, our planet's development depends on demographic changes that can dramatically change the balance in society.

The so-called "Industry 4.0" (Industry 4.0 and the fourth industrial revolution explained), first investigated in 2011, can lead to changes of such magnitude that humanity has not yet known. In the long run, the fourth industrial revolution may provoke improved efficiency and economic growth. However, Industry 4.0, often portrayed as a mathematical sign of infinity, can lead to imbalances and global unemployment in the short term. Consequently, we are talking about the total automation of most production processes and the lack of human resources. We call the current civilization development stage an information society dominated by digitalization, informatization, and digitalization. As a result, there is a tendency to form a single social, informational and educational space globally in modern education. The Internet plays the leading role in this process.

In the XXI century, there is a need for a new type of specialists who have a creative approach to solving various issues, strive for self-improvement and constant communication with other people, as well as willing to cooperate with artificial intelligence systems. In globalization, it is essential not to find a person for work but vice versa. This in turn, can provide a significant increase in efficiency. At the same time, it will not be the linear development of a career in one profession that will be important, but the search for one's mission and its realization in this direction. Global transformation requires us to make significant changes that can be achieved, including quality education and lifelong learning.

The agenda is the transition to an integrated educational model based on the transfer of knowledge and the human formation as the author of life. Lifelong education, as well as education not only of the mind but also of the heart, is of paramount importance. Heart education is now being actively talked about in Northern Europe. For instance, Swedish financier and entrepreneur Thomas Bjorkman (Yak diyaty dali: Hromadi pro stalyy rozvytok, 2020) is convinced that the connection between education and sustainable development is complex. We can teach people to care more about nature, society, but in order for profound change to happen, everything must go from within, that is, "from the heart." Today, the traditional school system is focused on teaching the mind, but "teaching the heart" is just beginning to be introduced into the existing education system. Our mind is a highly complex system that develops throughout life. Nevertheless, this requires special conditions that are created and provided by a particular educational model.

Based on the human development pace analysis, the Global Education Futures team has identified critical competencies and basic skills that can be the key to success in a new, challenging future. Let us dwell in more detail on the report "Educational ecosystems for societal transformation". The development dynamics require the construction of a wisdom-based society, which would combine individual and collective intelligence. However, a happy future is possible with the introduction of radical changes in education (Figure 19).

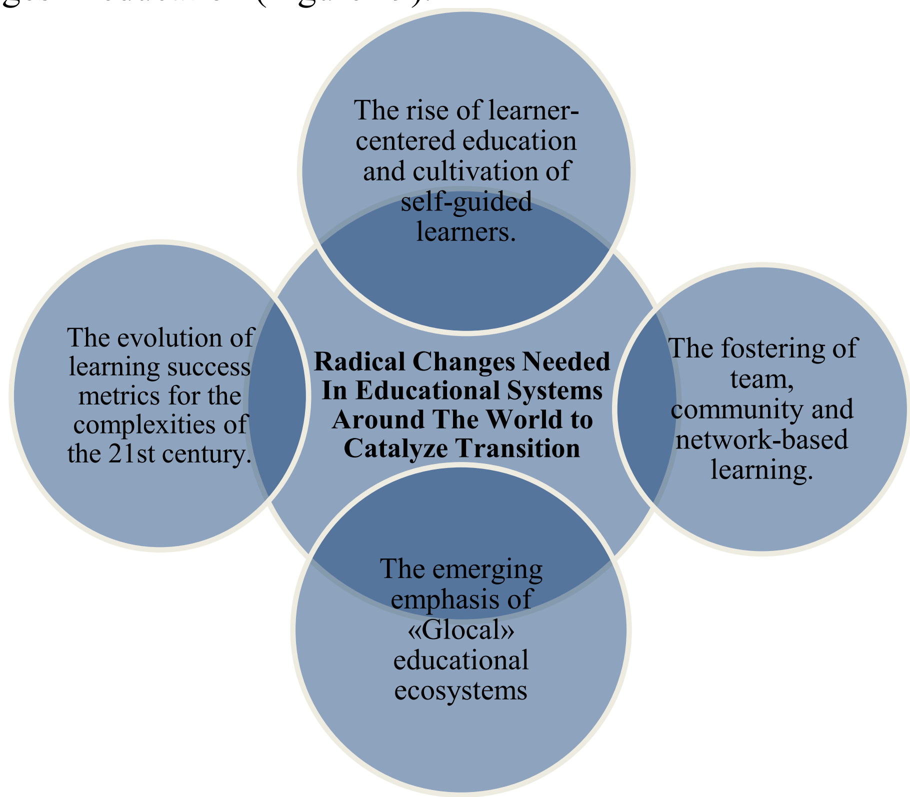


Figure 19. Radical changes that are needed in educational systems around the world to catalyze a transition

Source: built by the authors based on (Educational ecosystems for societal transformation, 2021)

In general, the main prerequisites for the new educational model formation are: socio-technical systems improvement; the VUCA-world; social, economic, and cultural transformations; unwillingness of the existing educational system to respond to the challenges of the XXI century and adapt to new, more complex, living conditions; accelerated pace of the fourth industrial revolution.

Model educational institutions should be our future foundation and provide lifelong learning. There are three vital elements to lifelong learning: community, business, and civil society. They must come together to develop creative and innovative development models. It is crucial to understand that the primary goal of higher education is not a diploma but the acquisition of particular competencies and skills. Thus, universities are a kind of center for the integration of lifelong learning. Previously, the basic skills model included two main elements: hard skills and soft skills. Over the past few years, this model has undergone significant transformations and is as follows. The first group consists of contextual or specialized skills, the second is cross-context, the third is meta-skills, and the last is existential (Figure 20).

These various layers of competencies also have various life cycles. For example, contextual skills can quickly become obsolete, primarily due to the rapid pace of digitization. Cross-contexts have a slightly longer life cycle, and, therefore, their mastery is longer in time. The last two groups of skills change very rarely and accompany a person throughout life.

CONTEXT-SPECIFIC SKILLS	CROSS-CONTEXTUAL SKILLS	META-SKILLS	EXISTENTIAL SKILLS
• bicycle riding, • video blogging, • tango dancing	• an ability to read and write, • time-management skills, • teamwork skills	• different modes of operating objects in our mind or in the physical world	• can be universally applied throughout lifetime and different living contexts on an individual

Figure 20. A new model of competencies
Source: developed by the authors

Thus, the basic skills of the XXI century are concentration and management of attention, emotional intelligence, digital literacy, creativity, ecological thinking, cross-culture, ability to self-education. The seven basic skills acquired by getting an education will help people adapt to a rapidly changing world and realize their potential. In the XXI century, the number of Internet users worldwide is growing steadily. For example, as of January 2021, the number of global smartphone users was 5.22 billion, the number of social network users was 4.2 billion. At the same time, the number of people using the Internet worldwide reached 4.66 billion, which is 316 million (7.3%) more than in the same period last year. Currently, the global penetration rate is 59.5%. Therefore, the spread of COVID-19 dramatically influences the number of Internet users (The Global State of Digital, 2021).

Under such conditions, online education is becoming a popular product in educational services, and blended learning is increasingly popular. It is believed that the transition to blended learning will save time for both teachers and students. The traditional audience at the university is relegated to the background, and, according to statistics from Internet users, it is much more convenient for a student to work from a smartphone or computer. Of course, it is difficult to talk about a complete transition to online education now, but over the next 10 years, this form of education may become dominant. There is a close connection between the development of education and globalization in the world. As a result, online education is already an essential element of sustainable development.

In its report on the development of education, Global Education Futures says that learning methods such as memorization will be unnecessary in the transition to online education, but insight will be necessary, for example. However, online education has not yet found proper recognition in the labor market. Criteria for evaluating various online courses' efficiency are being developed. On the agenda is establishing that a person has passed the exam on taken a specific course. The solution to this issue is to invest heavily in new technologies and processes. The main competitor of the new model of education is traditional education.

In 2012, Massive Open Online Courses (MOOCs) appeared on the educational services market, promising to transform the educational model. However, in 2019, researchers at the Massachusetts Institute of Technology (MIT) reported that online courses did not fulfill their original task (Why MOOCs Didn't Work, in 3 Data Points, 2019). In the paper "The MOOC Pivot" in the journal "Science", the Massachusetts Institute of Technology's Justin Reich and José A. Ruipérez-Valiente highlighted the significant miscalculations of MOOCs:

1. The completion rate was relatively low, i.e., students who studied in the first year very often did not return to study in the future. During 2017-2018, 3.13% of participants completed the courses compared to 2014-2015 - 6%. The completion rate did not increase in the following years.
2. Despite the declared democratization of education, many participants in online courses lived in relatively developed, wealthy countries. Thus, in 2017–2018, 68.7% (954,426 people) of participants came from countries that belong to the "very high level of development"; 15.9% and 14% respectively - from countries with high and medium levels of development. Furthermore, only 1.43% (55,000 people) came from low-income countries (The MOOC pivot, 2019).

+ opportunity to listen to the courses of the most authoritative teachers from all over the world;

+ access to the latest, up-to-date information;

+ lower cost than full-time study at the university (often the courses are free);

+ the opportunity to study at a convenient time in any city on the planet where there is Internet access;

+ obtaining certificates of relevant courses completion.

- difficulties with self-discipline and self-motivation (online courses will not be useful for everyone);

- very often the materials are oversaturated with theory in order to reach a large audience;

- problems with the recognition of certificates among employers who much more trust traditional diplomas;

- lack of live communication;

- problems with assessing the usefulness of the course taken.

Figure 21. Advantages and disadvantages of MOOCs

Source: developed by the authors

We, in turn, can highlight the following advantages and disadvantages of MOOCs (Figure 21). Given the prevalence of COVID-19, MOOCs growth statistics should be revised (Figure 22). As for the number of students, in 2015 there were 35 million, in 2016 - 58 million, in 2017 - 81 million, in 2018 - 101 million, in 2019 - 120 million, in 2020 - 180 million (By the numbers: MOOC in 2020) from statistics we see that the number of participants has actively increased in 2020, this is primarily due to the epidemiological situation in the world and the spread of COVID-19.

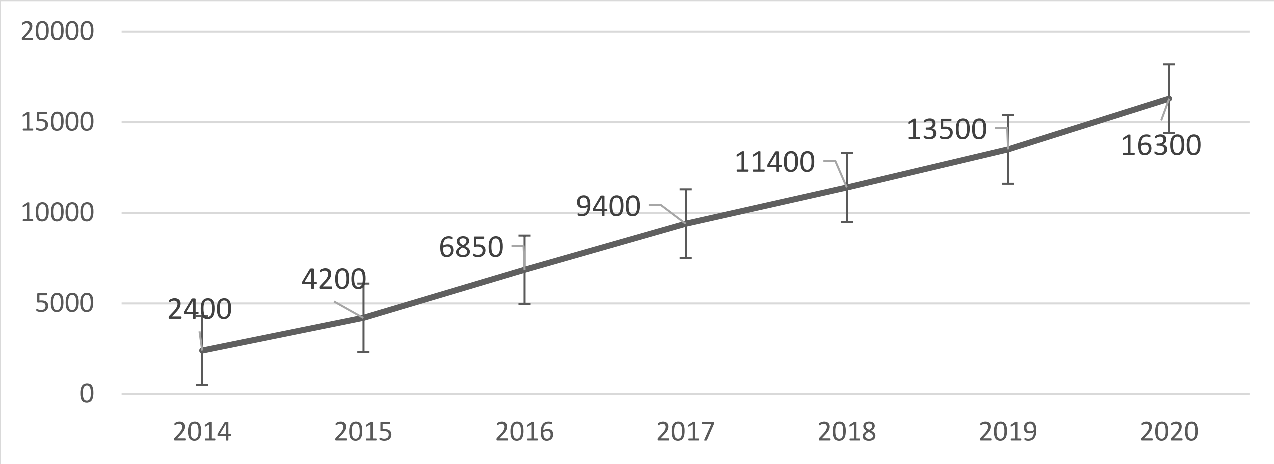


Figure 22. Growth of MOOCs.

Source: built by the authors based on (Online Education for Sustainable Development, 2021)

The Observatory on Borderless Higher Education (OBHE) announced the recognition of digital learning in August 2021 and invited everyone to join the discussion on online education efficiency in the #BorderlessConversation conversation. OBHE is a global strategic information service tracking trends and developments in borderless higher education (#BorderlessConversations Episode 4 | Recognising Digital Learning, 2021).

The leading providers of online education are Coursera, edX, FutureLearn, Swayam. Thus, the president of edX, Anant Agarwal, in 2017 stated that by 2020 the number of users of this platform would be 1 billion participants (Educational ecosystems for societal transformation, 2021). However, according to statistics, as of 2020, their number is 35 million (By the numbers: MOOC in 2020).

Achieving the 17 UN Sustainable Development Goals by 2030 should lead us to a happy future in which global challenges will be overcome: poverty, inequality, the adverse effects of climate change, wars, conflicts, and others. An essential condition for this happy future is the acquisition of knowledge. However, this process requires much effort in terms of informatization because a person has to filter from the array of information only crucial.

UNDP Ukraine, in partnership with German development agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, has presented three new online courses to support sustainable development in Ukraine:

1. Act further: Sustainable development for civil servants.
2. Act further: Sustainable development for businesses.
3. Act further: Sustainable development for civic activists (Online Education for Sustainable Development, 2020).

The course “Act further: Sustainable development for civil servants” was part of the general professional (certificate) training program for civil servants and local government officials, accredited by the National Agency for Civil Service, implemented based on the Ukrainian School of Government. The total amount of this program is 2 ECTS credits (60 hours), of which 40 hours are allocated for the online course and 20 hours for the training part. In addition, a 40-hour certificate is issued based on the results of the online course. The course aims to increase the capacity of public servants to analyze, formulate and implement a public policy for sustainable development of territories through the development of effective multilevel governance in Ukraine. The activities of public servants should be based on a partnership to achieve the Sustainable Development Goals (Yak diyaty dali: Derzhavnym sluzhbovtsyam pro stalyy rozvytok, 2020).

UNDP analysts, experts on sustainable development, government and local officials, and university professors prepared the course. During this process, the fundamental challenges for Ukraine on achieving 17 Sustainable Development Goals for the period up to 2030 were identified.

The developers anticipate that in taking this course, a participant can raise awareness about the Agenda for Sustainable Development until 2030, global trends, and best global practices for implementing the Sustainable Development Goals. Moreover, to form a new vision of building partnerships and forming a community around common goals and interests. In addition, the course provides an understanding of the practical aspects of developing and implementing an effective public policy for sustainable development, monitoring and evaluating the results.

The course “Act further: Sustainable development for businesses” is aimed at small and medium business owners who are interested in:

- further business development;
- creation of long-term values;
- positive social and environmental impact.

A vital component is developing functional partnerships with all stakeholders: employees, consumers, communities, etc. The course consists of four modules, each of them provides expert comments, practical advice, examples from the European experience of implementing the Sustainable Development Goals of small and medium-sized businesses.

This course aims to understand the causal links between the economic, environmental, and social components of public life. Provides an understanding of how to define the goals and objectives of sustainable development for business, involve stakeholders in the partnership, integrate into their activities and contribute to achieving the Sustainable Development Goals.

The course “Act further: Sustainable development for civic activists” is aimed at representatives of public organizations and united territorial communities, community leaders, and activists. The course structure is built according to four levels of sustainable development: ecology, society, economy, and partnership. In total, the course involves 19 classes.

Free courses make online education much more accessible, as it requires only the desire and access to the Internet. Furthermore, completing the course allows obtaining a certificate of 60 hours (2 ECTS credits), which is entered in the relevant register. However, it should be noted that taking the course and obtaining a certificate may not be a sufficient basis, for example, for employment. After all, as mentioned above, not all employers trust online education.

April 19, 2021, The European Union and the United Nations Development Program (UNDP) in Ukraine have announced the launch of a series of online courses on “Association of apartment building co-owners: the alphabet of success”, which include group and individual consultations, the primary purpose of which is the implementation of sustainable energy efficiency solutions.

In any case, the implementation of the project “Online Education for Sustainable Development” has a positive impact on integrating the Sustainable Development Goals into life and awareness of the causal links between economic, environmental, and social components of public life. The quintessence of all courses, regardless of the audience to which they are aimed, is the awareness of responsibility for the consequences of our lives on this planet.

Historian and author of the bestseller “Sapiens. The history of humankind” Yuval Noah Harari, during an online discussion of the Yalta European Strategy (YES) said: “What is Covid in 50 years? It may be remembered as the watershed when the world truly became digital and mass surveillance or tracking became normal and acceptable in much of the world. That is a reason to worry.” Historian Rutger Bregman, in turn, is convinced that “We have seen some limits to digitalization. For example, in education, it was fashionable to say, “Everything will be digital,” but we made sure that physical contact was significant for the education system. We remain physical beings in this sense” (Kharari ta Brehman otsinyly perekhid osvity v onlayn, 2021).

Spring, 2020 - all educational institutions in Ukraine switched to distance learning, which created many problems. Teachers and professors were not quite ready for this form of learning and were forced to adapt concisely to new, challenging conditions. At the same time, there was another problem related to Internet access, which was complained about by 46.9% of employees of educational institutions. There was also an increase in self-study material, which involved sending information from the textbook without discussion, feedback, or explanation.

According to the observations, UNDP has led to growing digital inequality and deteriorating mental health (increased stress and anxiety). Also, the transition to distance education during a pandemic can have a long-term impact on educational outcomes, especially among vulnerable populations. In addition, due to forced isolation at home, the number of domestic violence cases in Ukraine has increased (Koronavirus ta osvita, 2021). Thus, the impact of the COVID-19 pandemic has not just damaged economies; it has exposed inequalities and set back progress in development by years.

Like other global transformations in human history, online education has divided society into supporters and opponents. Discussions between them have intensified since the world entered a new crisis - the spread of coronavirus infection. However, it must be understood that the impact of globalization on changing the form of learning is inevitable, and the transition to online education will take place regardless of our desire.

Here are the main advantages of the transition to online education:

1. The opportunity to receive education without leaving the main activity. This point is relevant due to today's changes, for example, in the medical field. Thus, the functions of the chief physician become managerial, which forces to acquire appropriate skills. Learning at a convenient time anywhere makes education more accessible.
2. The opportunity to get an education for those groups of people who, due to limited physical abilities, cannot study in classrooms.
3. The ability to regulate the time, rationally distribute it, and acquire knowledge in a comfortable environment;
4. Significant expansion of the target audience, etc.

Among the disadvantages of online education are the following:

1. The most important thing is the lack of "live" learning, communication, and social interaction.
2. Not every profession can be mastered online. If entrepreneurship, marketing, PR, IT, SEO, journalism, SMM, copywriting, content marketing can be mastered online, then the profession of a doctor will be challenging to master.
3. Difficulties with self-discipline and self-motivation, lack constant habitual control of the teacher.

After listening to online courses, we note that distant education for sustainable development covers education and training's environmental, economic and social issues. It is essential to form a new system of values and patterns of the younger generation's behavior. Online education for sustainable development significantly complements and expands the framework of environmental education and allows all aspects of educational activities to develop in sustainable development. Also necessary is the practical implementation of the sustainable development models, the appropriate norms of behavior and lifestyles formation, an active public position on the implementation of sustainability in the daily experience of children and adults. We support the idea that sustainable development should be a universal and necessary element of everyday life and should be included in all subjects and disciplines.

In order for online education for sustainable development to be successful, several key points need to be considered:

- strengthen cooperation and partnership of all globalization educational process participants;
- contribute to the understanding of the essence of global, national, and local environmental problems with an emphasis on their socio-economic consequences;
- introduce new approaches to learning, namely to promote lifelong learning.

Distant education does an excellent job of informing society members about the main problems of sustainable development and attracting a large audience. A substantial role in this process is given to digitalization and informatization. Online courses confirm that the priority problem is to preserve humanity and the Earth's biosphere by significantly reducing anthropogenic pressure on the environment. Maintaining the balance is possible only in a global partnership, which the Sustainable Development Goals provide.

Thus, online education for sustainable development aims to form a personality that strives for constant self-education and creative thinking. A vital task of online education is to build a so-called knowledge society. Education is a basis for society and economy, a leading factor in social changes and economic growth.

3.2. Advanced education as a basis for the transition to sustainable models: production and consumption

Knowledge sharing is a fundamental component of achieving Sustainable Development Goals. In the XXI century, education must be proactive, forward-looking. The idea of advanced education was first formulated in a report to the Club of Rome "No limits to learning", prepared in 1979 by J. Botkin, E. Elmandjra, and M. Malitza (Botkin et al., 1979). Advanced education for sustainable development must consider changing social trends and have an innovative, predictive nature. The concept's essence of advanced education is to prepare people for new living conditions. A person should receive such knowledge that would allow one to act effectively in the information environment. Advanced education should form a person's idea of his or her role on this planet and encourage humanity and natural environment preservation. Thus, advanced education is aimed at:

- successful civilization future;
- creative human skills development;
- creative thinking formation.

The modern educational process trends influence advanced education formation as openness, continuity, humanization, humanitarianization, and democratization. Due to the 12-the Sustainable Development Goals goal, one of the main tasks is to implement the "Ten-Year Strategy for Action on the Transition to the Use of Rational Consumption and Production Models" with the participation of all countries and taking into account the countries' development and potential. It is assumed that developed countries should be the first to start it (GCNI. Sustainable Development Goals).

Sustainable consumption and production essence use a systematic approach to minimize the negative impact on the environment caused by society's consumption and production system. Among the measures for the transition to rational consumption and production models should be noted the following:

- to develop rationally and to use natural resources efficiently;
- to halve the total food waste amount at the retail and consumer levels per capita;
- to reduce food losses in production and distribution chains;

- to achieve environmentally friendly use of the chemicals and all wastes throughout their life cycle per agreed international principles;
- to reduce the ingress of chemicals into the air, water, and soil to minimize their negative impact on human health and the environment;
- to reduce waste significantly by taking measures to prevent its generation, reduction, recycling, and reuse;
- to encourage large and multinational companies to apply sustainable production methods and reflect information on the rational use of resources in their reports;
- to promote sustainable public procurement practices according to the national strategies and priorities;
- to provide people around the world with information on sustainable development and lifestyles in harmony with nature;
- to assist developing countries in building their scientific and technological capacity to move to more rational consumption and production patterns;
- to develop and implement tools for monitoring the sustainable tourism impact on sustainable development, which contributes to job creation, local culture development, and local products production;
- to rationalize inefficient subsidies for the use of fossil fuels, which leads to wasteful consumption (Sustainable development GOALS. Goal 12: Ensure sustainable consumption and production patterns).

Sustainable consumption and production are aimed at "doing more and better" while using fewer resources. This, in turn, will reduce degradation and pollution throughout the life cycle while improving the quality of life. Sustainable production and consumption require the various stakeholders' participation, including entrepreneurs, consumers, politicians, researchers, scientists, retailers, journalists, development cooperation institutions, and others. At the same time, it is essential to involve consumers through educational and training initiatives on sustainable consumption and lifestyle; provide consumers with sufficient information through standards and labeling; organize public procurement, consider sustainability principles, etc.

There are four main obstacles to achieving the Sustainable Development Goals:

- low awareness of personal responsibility for sustainable development;
- low awareness of sustainable development and 17 Sustainable Development Goals;
- non-compliance with human rights;
- irresponsible consumption and production.

It should be noted that in particular goods or services production, people use primarily exhaustible resources. However, these exhaustible resources are used in part and thus generate many tons of industrial waste, i.e., garbage. In this context, the person's ecological footprint is vital, measured by the number of resources one needs for everyday existence. This indicator growth threatens sustainable development in general and may be an obstacle to achieving the 12th Sustainable Development Goal, in particular. Therefore, excessive consumption is a dangerous social trend and a threat to human existence.

A logical question arises: how many natural resources will suffice at such a consumption rate to provide humanity with everything it needs? Figure 23. shows the world energy consumption in 2019 structure. According to scientists, with such exhaustible coal resources consumption rates, we will have enough for 250 years, oil − for 30-40 years, natural gas − for 50-70 years (*Statistical Review of World Energy, 2020*).

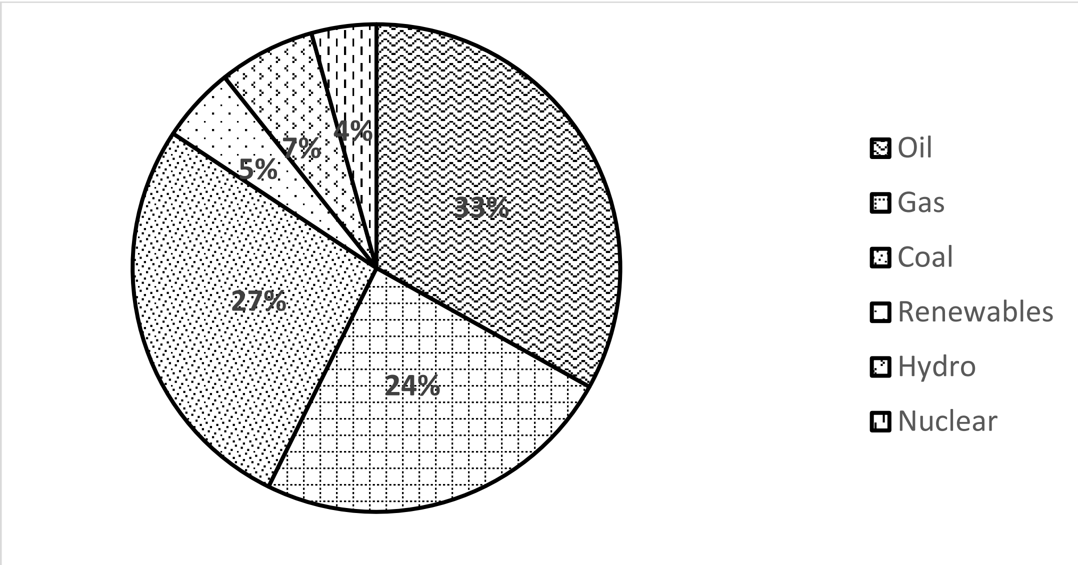


Figure 23. Fuel shares of primary energy and contributions to growth in 2019
Source: developed by the authors based on Statistical Review of World Energy (2020)

The sixth edition of the Global Environment Outlook (GEO-6) (Global Environment Outlook 6, 2019) provides an expanded analysis of the current environment from 2012 to 2019. The purpose of this report is to achieve economic prosperity, people's health, and well-being, i.e., the direction of all efforts for a sustainable future. A healthy planet is needed to achieve sustainable development. However, today we are observing negative trends. Population growth, increases in resource use, lead to unsustainable production and consumption patterns. Contamination of freshwater systems by 2050 will lead to antimicrobial resistance, becoming one of the leading death causes. The report also notes that today humanity is not moving towards achieving Sustainable Development Goals. In this case, their achievement becomes impossible neither by 2030 nor by 2050 (Human health in dire straits if urgent actions are not made to protect the environment, warns landmark UN report, 2019).

The report's authors call for action to reduce the plastic pollution flow, which annually, according to the UN, brings 8 million tons of garbage to our oceans. Furthermore, this is one garbage truck every minute. With the COVID-19spread, this problem has become even more acute. According to research by the international audit and consulting network BDO, waste generation during the coronavirus epidemic has become a new form of global pollution. In addition, introduced quarantine, isolation, and social distancing have led to a significant increase in household (15-25%) and medical waste in health care facilities (10-20 times) (How does COVID-19 impact the environment? 2021).

On January 1, 2021, the International Convention on the Prohibition of Richer Countries from Exporting Plastic Waste for Recycling to the Poor One entered into force. As a result, the ocean is projected to become cleaner in five years. Currently, developing countries (such as Vietnam or Malaysia) recycling and accept garbage from other countries. Nevertheless, the problem is that it is almost impossible, at first glance, to determine whether a batch of plastic is recyclable. Many non-recyclable wastes are illegally incinerated or dumped in landfills or waterways. As a result, only 9% of all plastic ever produced has been recycled. About 12% has been incinerated. The other 79% has accumulated in landfills, dumps, and the natural environment, where it often ends up washing into rivers via wastewater, rain, and floods. Much of it eventually ends up in the ocean. To date, most plastics are produced in the United Kingdom and the United States (New rules to tackle 'wild west' of plastic waste dumped on poorer countries, 2020).

Today we live by the linear principle (Figure 24), i.e., we extract resources, produce goods, consume them and throw them away. However, this principle cannot be lived on a planet with exhaustible resources.

Figure 24. Linear economy.
Source: developed by the authors

Resources extraction in a non-environmental way threatens the Sustainable Development Goals achievement, in particular, 3(Good health and well-being), 6(Clean water and sanitation), 7(Affordable and clean energy), 8(Decent work and economic growth), 13 (Climate action), 14 (Life below water), 15 (Life on land). However, the 12th Sustainable Development Goal directly impacts the 13th goal, namely the fight against climate change. Thus, we must ensure efficient resources use and help to reduce waste. It is necessary to use innovative technologies that reduce the economic resource intensity, ensure sustainable use of chemicals, reduce waste. Today, the circular economy, which involves the reuse of resources, is becoming more widespread (Figure 25).

As a critical consumption dimension in a sustainable development society, sustainable consumption is vital to addressing global challenges. Everyone can learn sustainable consumption if they start asking themselves: what are we buying? how is it made? where does the waste go? It is necessary to bring up regular habits in consumers' behavior since childhood. Educational institutions play a crucial role in this process. Therefore, they must pay considerable attention to the sustainable development and sustainable consumption topic. In this case, the greening of education (formal and informal) is essential. The transition to production and consumption sustainable forms is possible by forming environmental awareness, environmental values, and environmental education.

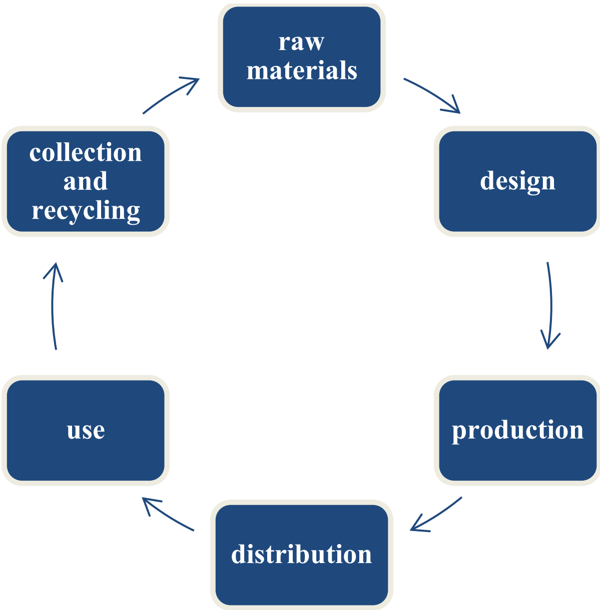


Figure 25. Circular economy
Source: developed by the authors

Currently, "Ecology" is not a mandatory subject to be studied in educational institutions. However, the updated Law of Ukraine "On Education" (Zakon Ukrayiny "Pro osvitu", 2017) such a tool as cross-cutting meaningful lines of education to all subject areas is being introduced. Cross-cutting lines are a means of integrating key and general subject competencies, subjects, and subject cycles. Cross-cutting lines, as socially critical cross-curricular topics, help form students' ideas about sustainable development and develop the ability to apply the acquired knowledge in different situations. The purpose of cross-cutting lines is to focus teachers' attention and efforts on expanding and improving key competencies. For example, the cross-cutting line "Environmental Security and Sustainable Development" is the students' social activity, responsibility, and environmental awareness formation. They will treat the environment carefully and responsibly, recognizing the importance of sustainable development for the environment and society (Naskrizni zmistovi liniyi).

The education greening is aimed at forming a person with an ecocentric consciousness. Curricula should include environmental competence, which includes the following elements: a set of environmental knowledge, skills, abilities acquired as a result of training; intellectually and personally conditioned integral social and professional property of the educational institution's graduate; effective use of acquired knowledge and skills to minimize the harmful effects on the environment in the activation process.

It is vital to update the content of existing disciplines and supplement them with environmental aspects. Furthermore, training should align with the new modern world challenges and be subject to implementing internationally agreed approaches to "education for sustainable development." According to the new living conditions, the prominent role of advanced education for sustainable development is to train specialists “on time”. Today, it is crucial that a higher education institution’s graduate has the knowledge and practical skills that would allow him or her to adapt to the new society of transformation and actively influence the preservation of the biosphere for sustainable development.

Energy-saving and eco-balanced consumption models in the XXI century should be fashionable and the basic principles in human life. Although we have discussed the Internet’s positive impact on obtaining online education in the previous paragraph, it has the opposite meaning of rational consumption. Various goods and services advertising, blogging development leads to consumption. Then there is a need to teach consumer culture. The first step to sustainable consumption is to reduce electricity and water consumption. According to the Worldometer website, which contains real-time statistics, as of August 28, 2021, 7,889,142,100 people live in the world, of which 10% (788,948,460 people) do not have access to safe water (Worldometers, 2021).

The New York Times has published an interactive map illustrating the leading climate change risks for every country in the world. It notes that in Ukraine in 2040, the main danger may be water shortages (Every country has its own climate risks. What`s yours? 2021). Therefore, we need to consume water wisely. For example, pour into a kettle as much water as needed for morning coffee. This, in turn, saves both water and electricity. In addition, we need to buy appliances with low energy consumption, which are marked "A" or "A +". For instance, a refrigerator of this class will consume 30-50% less electricity than a device of the same volume of brand "B". It is also needed to use energy-efficient light bulbs, such as LED (energy-saving) light bulbs, which do not contain harmful substances. In some cases, energy-saving appliances’ prices may be higher, but it should be understood that the purchase of energy-efficient goods makes a person a conscious consumer, regulates the market and forms sustainable ways of consumption.

On March 22, World Water Day is celebrated, on June 5 11 – World Environment Day (International days). Therefore, it is essential to hold educational institutions events to inform students about ways to save energy and alternative energy sources and tell why it is crucial to saving energy on such days. The students’ project activity allows them to combine theoretical knowledge and practical skills to ensure the rational resources’ use and sustainable development, which is also of great importance for the ecological worldview formation. Energy efficiency largely depends on the involvement of citizens in the energy-saving process and is the most affordable, quick way to solve the problem of civilization’s dependence on non-renewable resources.

Advanced education’s role in energy efficiency is manifested in several crucial sustainable development elements:

1) it contributes to the human skills of responsible consumption formation.
2) it provides training in scientifically sound methods of energy efficiency. Theoretical knowledge is not enough to be energy efficient; practice is also needed.
3) it transits to sustainable consumption patterns process is the justification and training to limit the use of energy and resources consciously.

The role of education as a basis for the transition to sustainable production and consumption models is as follows:

- knowledge about ecological problems of the region, country, and the world formation;
- holistic picture of human-environment interaction formation;
- ability to properly assess the situation related to the global problems and make rational decisions to overcome the challenges facing humanity formation;
- students' participation in the energy-saving process promotion;
- environmental culture, involvement in the environmental movement, development of environmental organizations at the level of school and out-of-school educational institutions arises.

Teachers, professors, and other participants in the educational process face severe challenges in the better future pursuit. The advanced education concept implies that the teacher must perform the functions of interlocutor, expert, facilitator, researcher, tutor. The teacher must become a kind of mediator for students and convey the basic sustainable development principles. In this case, the teacher must know his subject well and know the unique and essential sustainable development aspects. Many teaching methods for sustainable development are available today:

- conducting seminars related to sustainable development by state or environmental organizations specialists;
- discussion a relevant and interesting article that would relate to sustainable production and consumption at the seminar;
- holding training, conferences, discussions on the caring for our planet topic;
- conducting role and simulation games, quests.

Since 2018, the National Educational Platform, where the digital educational ecosystem is developing, has been operating in Ukraine. It includes electronic textbooks with virtual 3D materials that teachers can compose at their discretion, textbooks for download, interactive laboratories, virtual museums, forums for teacher communication, education management systems. The national electronic education platform should become a driver of significant changes in the educational process and launch a market for the electronic educational products and services production, contributing to participants' formation in the educational process in Ukraine's digital competence (Institute of Education Content Modernization).

Ukraine has also created an exceptional educational and methodological resource for teachers to implement the cross-cutting content line "Environmental safety and sustainable development" (EcoMON) (Navchano-metodychnyy resurs dlya pedahohichnykh pratsivnykiv z realizatsiyi naskriznoyi zmistovoyi liniyi "Ekolohichna bezpeka ta stalyy rozvytok", 2020). The website contains information for teachers (including the UN Sustainable Development Goals), lesson materials, presentations, films, animations, and ready-made practical tasks examples. Information cases for teachers are also available, covering all life situations related to consuming or using various goods, services, energy, water, and other resources. The project team hopes to achieve tangible results in behavior change and motivate the younger generation to reduce their environmental footprint and lighten their environmental backpack.

During the last 30 independent years, Ukraine has opened to the world many innovative inventions that have practical applications in various life spheres. For example, in the transition to sustainable production and consumption conditions, the invention of Doctor of Technical Sciences Oleksiy Onipko, on which he worked for 10 years, is - a high-efficiency windmill Onipko Rotor, which has a spiral shape. This is the invention's main advantage because traditional windmills with blades require a speed of at least 3 meters per second (Unikalni ta perspektyvni: innovatsiyni rozrobky ukrayintsiv, shcho nevdovzi pidkoryat ves svit, 2021).

Another Ukrainian startupper's invention, important for rational consumption, is making paper from fallen leaves RE-leaf PAPER. This invention makes it possible to replace exhaustive resources for paper production − forests with a constantly renewable resource − leaves. Moreover, much ecological paper production can reduce plastic bags, which considerably pollute biosphere use (Unikalni ta perspektyvni: innovatsiyni rozrobky ukrayintsiv, shcho nevdovzi pidkoryat ves svit, 2021).

As mentioned above, the environmental education processes are directly related to the practical educational institution functioning component. Energy-saving, efficient water consumption, separate collection of solid waste, and proper management of hazardous waste will reduce the burden on the environment. Based on this, an environmental standard was developed for educational institutions, "Green Class", which covers the significant environmental educational institutions impacts. The main "Green Class" element integrates the environmental component into education and upbringing, aimed at comprehensive younger generation and citizens training. This principle provides for the educational institutions' certification according to ISO 14024: 2002 (from January 1, 2022 - ISO 14024: 2018), which will determine whether the educational or educational institution meets the requirements of environmental criteria (Zelenyy klas).

Thus, the new challenges the world and Ukraine face today require changes in established governance systems and public and economic relations models. The impact of consumption on the environment can be mitigated by shifting demand from higher-impact to lower-impact consumption categories, i.e., by changing traditional approaches to consumption to sustainable approaches. An essential element in achieving the Sustainable Development Goals is quality, advanced education, considering future trends, forming environmental awareness, and expanding and improving critical competencies. The priority is to update educational standards and the entire educational process, including inclusive and digital elements. Therefore, the educational sphere is the substantial element to make the synergies to accelerate the Sustainable Development Goals formation achievement possible.

3.3. The main state policy directions to implementing the education system for sustainable development

Exploring almost any issue, one can come across the concept of development. This term is primarily used in a positive context, such as developing the economy, culture, technology, education, etc. Moreover, the concept of "sustainable development" immediately suggests stable growth. However, the term is the official paradigm of the United Nations, first defined in 1987 as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UN Documents. Gathering a body of global agreements. Our Common Future, Chapter 2: Towards Sustainable Development). Thus, any decision that benefits now but harms future generations does not fit into this concept and must be rejected.

It should be noted that the idea of sustainable development is very progressive; its strategic goals are somewhere in the far future. This concept has, to some extent, become a response to the modern, high-speed world, which never sleeps and is constantly rushing somewhere. It allows us to think about what will happen after us.

Sustainable development has three critical sub-components of its provision: economic, social, and environmental (Fig. 27).

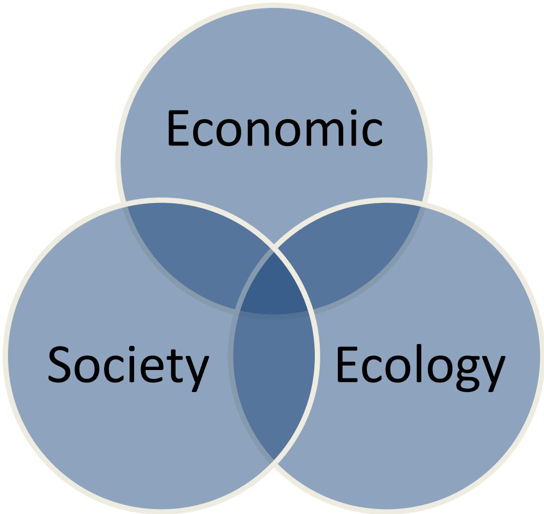


Figure 27. Sustainable development sub-components
Source: developed by the authors due to the sustainable development concept

Sustainability is a paradigm for thinking about the future in which environmental, societal, and economic considerations are balanced in the pursuit of improved quality of life (Sustainable Development).

It is clear that such a development is a very serious task for the whole world, and requires the efforts not only of one country or economy (even a powerful one), but of a general consolidation of states. In order to clearly understand the guidelines for sustainable development, in September 2015, the United Nations Summit adopted 17 Sustainable Development Goals. The approved goals have 169 tasks to achieve. They are designed for 2015-2030 and have replaced the previous Millennium Development Goals.

The Sustainable Development Goals are a call for all countries – poor, rich, and middle-income – to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address various social needs, including education, health, social protection, and job opportunities, while tackling climate change and environmental protection (17 Goals to Transform Our World). Sustainable development goals are also called global goals - they are interconnected - the key to success in one of them is to address issues that are generally related to others (What are the Sustainable Development Goals?). In figure 28. the list of purposes and their official illustrations of the UN is given. These icons have already become recognizable.

Figure 28. UN Sustainable Development Goals
Source: What are the Sustainable Development Goals?

Ukraine has also joined the initiative to achieve the goals mentioned above. At the legislative level, the period up to 2020 was regulated by the Decree of the President of Ukraine “On the Sustainable Development Strategy of Ukraine – 2020”, adopted on January 12, 2015 (Ukaz Prezydenta Ukrayiny “Pro Stratehiyu staloho rozvytku “Ukrayina – 2020”, (2015).

This document defined the purpose, vectors of the road map, priorities, and indicators of appropriate defense, socio-economic, organizational, political, and legal conditions of Ukrainian development for 2015-2020. During this period, 4 key vectors were identified (Fig. 29.

For each of the vectors, a list of reforms and changes in the ordinary life of every Ukrainian was planned. For example, according to the security vector, education reform was also included in the plan.

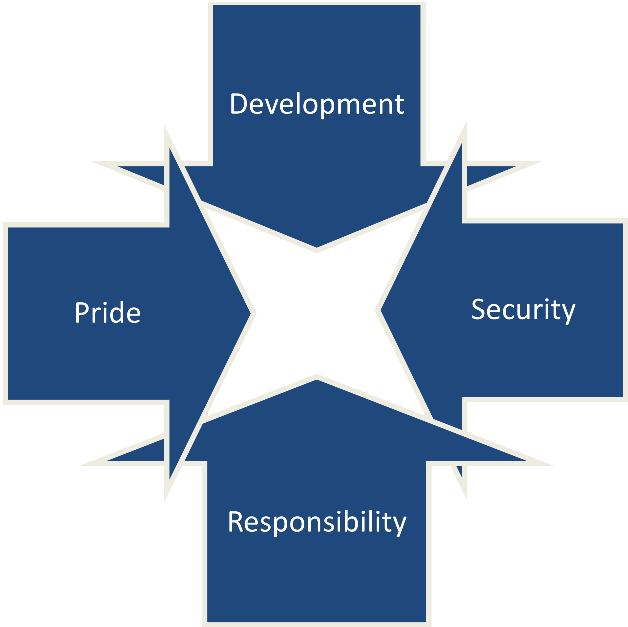


Figure 29. Key vectors of Ukraine's movement towards sustainable development

Source: built by the authors based on Ukaz Prezydenta Ukrayiny "Pro Stratehiyu staloho rozvytku "Ukrayina – 2020" (2015)

An exciting program of Ukraine's popularization in the world and national interest's advancement in the global information space was also established. The program's main goal was to build trust in Ukraine, position it in the world in favor of its political and economic interests, strengthen its national security and restore territorial integrity.

The program focused on providing:

- strengthening the institutional capacity for international strategic communications;
- synergies government, business, and civil society efforts to promote Ukraine in the world;
- increasing and optimizing Ukraine's presence at international events and venues; presence in the international academic, cultural and public environment;
- communication on the reforms and transformations in Ukraine success;
- formation and promotion of the brand messages about Ukraine: a country of freedom and dignity; a reforming country despite challenges; a hub for investment; a country of high technologies and innovations; a country attractive for tourism; a country with outstanding cultural and historical traditions;
- regular open dialogue with the world opinion leader's community, experts, and media that cover or comment on Ukrainian issues;
- formation of sustainable, effective communications with the Ukrainian diaspora and use of its potential.

In 2019, the President of Ukraine issued a Decree "On the Sustainable Development Goals of Ukraine until 2030" in which was stated that to ensure the national interests of Ukraine for sustainable economic development, civil society, and the state to achieve growth, quality of life, constitutional rights and freedoms to ensure compliance with the Sustainable Development Goals of Ukraine until 2030 (Ukaz Prezydenta Ukrayiny "Pro Tsili staloho rozvytku Ukrayiny na period do 2030 roku", (2019):

1) poverty overcoming;
2) hunger overcoming, achieving food security, improving nutrition, and promoting sustainable agricultural development;
3) ensuring a healthy lifestyle and promoting well-being for all at any age;
4) ensuring comprehensive and equitable quality education and encouraging lifelong learning opportunities for all;
5) ensuring gender equality, empowerment of all women and girls;
6) ensuring the availability and sustainable management of water resources and sanitation;
7) ensuring access to inexpensive, reliable, sustainable, and modern energy sources for all;
8) promoting progressive, inclusive, and sustainable economic growth, full and productive employment, decent work for all;
9) creating sustainable infrastructure, promoting inclusive, sustainable industrialization and innovation;
10) inequality reduction;
11) ensuring cities and other settlements openness, security, vitality, and environmental sustainability;
12) ensuring the transition to rational models of consumption and production;
13) taking urgent measures to combat climate change and its consequences;
14) conservation and rational use of oceans, seas, and marine resources in the sustainable development interests;
15) protection and restoration of terrestrial ecosystems and promotion of their rational use, rational forest use, combating desertification, land degradation stopping and reversing, and the process of biodiversity loss stopping;
16) promoting a peaceful, open society in the interests of sustainable development, ensuring access to justice for all and creating practical, accountable, and participatory institutions at all levels;
17) strengthening the means of implementation and intensifying work in the global partnership framework for sustainable development.

The goals of sustainable development of Ukraine for the period up to 2030 are guidelines for developing draft forecast and program documents; and state regulations to ensure a balanced economic, social and environmental dimension of sustainable development of Ukraine. In particular, Ukrainian experts, with the support of the United Nations Development Program in Ukraine and the Global Environment Facility, prepared a Strategy for sustainable development of Ukraine until 2030 draft within the framework of the project "Integration of the Rio Conventions into Ukraine's National Policy" (Proekt Stratehiyi staloho rozvytku Ukrayiny do 2030 roku).

Ukraine's strategic vision for sustainable development is based on ensuring national interests and fulfilling Ukraine's international commitments on the transition to sustainable development. This development involves:

- imbalances in the economic, social, and environmental spheres overcoming;
- economic activity transformation, transition to the principles of "green economy";
- building a peaceful, secure, socially cohesive society with good governance and inclusive institutions;
- ensuring partnership between public authorities, local governments, business, science, education, and civil society organizations;
- full employment;
- high level of science, education, and health care;
- maintaining the environment in a proper state that will ensure the quality of life and well-being of present and future generations;
- decentralization and implementation of regional policy, which provides for a harmonious combination of national and regional interests;
- national cultural values and traditions preservation (Proekt Stratehiyi staloho rozvytku Ukrayiny do 2030 roku).

Sustainable development is focused primarily on people and improving the quality of their lives in a favorable socio-economic environment and environmentally friendly, healthy, diverse natural environment. Furthermore, a high intellectual level of human potential should ensure the country's competitiveness in the future.

Quality education is the 4th goal of sustainable development. According to the UN, significant progress has been made over the past two decades. The overall school enrollment rate in developing regions reached 91% in 2015, and the number of out-of-school children worldwide has almost halved. Literacy has also risen sharply, and more girls are attending school than ever before. Achieving comprehensive quality education once again confirms that education is one of the most powerful and proven means of sustainable development. This goal guarantees free primary and secondary education for all girls and boys by 2030. It also aims to ensure equal access to low-cost vocational training, eliminate gender and material disparities and ensure universal access to quality higher education (Goal 4: quality education).

According to the draft "Strategy for Sustainable Development of Ukraine until 2030", strategic goal 4 is to protect the public health, well-being, and quality education in safe and sustainable settlements. This goal includes operational goal 4.2, providing inclusive and equitable quality education and promoting lifelong learning opportunities for all.

Tasks until 2030:

1. Provide equal opportunities for quality primary, basic and complete secondary education for every child, regardless of their health, place of residence, and family wealth.

2. Ensure equal and equitable access to quality development, care, and preschool education systems for all children, regardless of health, place of residence, and family wealth.

3. Provide equal access to quality vocational and higher education for the whole population throughout life, significantly increase the number of young and adults who have socially necessary skills, including vocational skills for employment, decent work, and entrepreneurship.

4. Eliminate gender inequality in education and ensure equal access to education and vocational training at all levels for vulnerable groups.

5. Ensure that all students acquire knowledge and skills on the principles of sustainable development, in particular, healthy lifestyles, human rights, environmental protection, gender equality, peace and non-violence culture promotion, national and patriotic education, and cultural diversity value awareness in the transition to sustainable development (Proekt Stratehiyi staloho rozvytku Ukrayiny do 2030 roku).

The Sustainable Development Goal 4 covers two main areas - providing comprehensive and quality education and promoting lifelong learning opportunities for all. The tasks performance degree to achieve quality education is determined by 14 indicators (Table 10) (Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020).

Initiated in 2016-2019, reforms in the field of education were aimed at:

- creating a modern, safe and inclusive educational environment, ensuring equal access to quality general secondary education (introduction of the New Ukrainian School), which meets the principles of child-centeredness, partnership pedagogy (teachers are motivated and qualified), end-to-end education process, based on competency-based learning, provides genuine autonomy of educational institutions and fair funding;
- ensuring the availability and realization of the right to receive vocational education, retraining, and advanced training for Ukrainians, including persons with special educational needs, as well as foreigners and stateless persons staying in Ukraine legally, respectively to their interests and abilities;
- implementing the significant changes in the management and financing of vocational education;
- reforming the principles of educational institutions funding - the advantage in financing is given to educational institutions for the training of students of technical, natural, and agricultural specialties (because the sustainable technological development of the country depends on them); higher funding will be given to those higher education institutions that have better results of their activities (higher employment of graduates, more orders from business and international grants, as well as included in international rankings); regional coefficient introduced, which provides additional funding for universities outside Kyiv (Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020).

Let us study the goal of sustainable development №4 tasks and achievement statistics.

Table 10

Achieving quality education tasks and indicators of their implementation

Code	Tasks	Code	Indicators
4.1.	Ensure access to quality school education for all children and adolescents	4.1.2.	Number of full-time secondary school pupils per teacher at the beginning of the school year
4.2.	Ensure the availability of quality preschool development for all children	4.2.1.	Children up to 5 years old coverage by preschool education
4.3.	Ensure access to vocational education	4.3.1.	Entrants to vocational education institutions number ratio to the total number of places in education institutions (vocational and technical) education, financed from state and local budgets
4.4.	Improve the higher education quality and ensure its close connection with science, promote the formation of cities of education and science in the country	4.4.1.	Number of Ukrainian cities members of the UNESCO Global Network of Learning Cities
4.5.	Increase the knowledge prevalence of among the population and skills required to get a decent job and business activities	4.5.1.	The level of population participation in formal and non-formal learning and training
		4.5.2.	The population that has been using Internet services for the last 12 months share
4.6.	Eliminate gender inequality among school teachers	4.6.1.	The share of men among teachers
4.7.	Create modern schools learning conditions, including inclusive, based on the innovative approaches	4.7.1.	General secondary education institutions in rural areas with access to the Internet share
		4.7.2.	General secondary schools in rural areas where computers are used in the educational process share
		4.7.3.	Full-time general secondary education institutions with inclusive education share

Source: Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020)

According to indicator 4.1.2 “Number of full-time secondary school pupils per teacher at the beginning of the school year” statistical achievement data are shown in Figure 30. Figure 30. indicates the planned 2020 target achievement at 9.5 secondary school students per teacher (Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020). This indicator has grown steadily over the last six years (since adopting the Sustainable Development Goals in 2015).

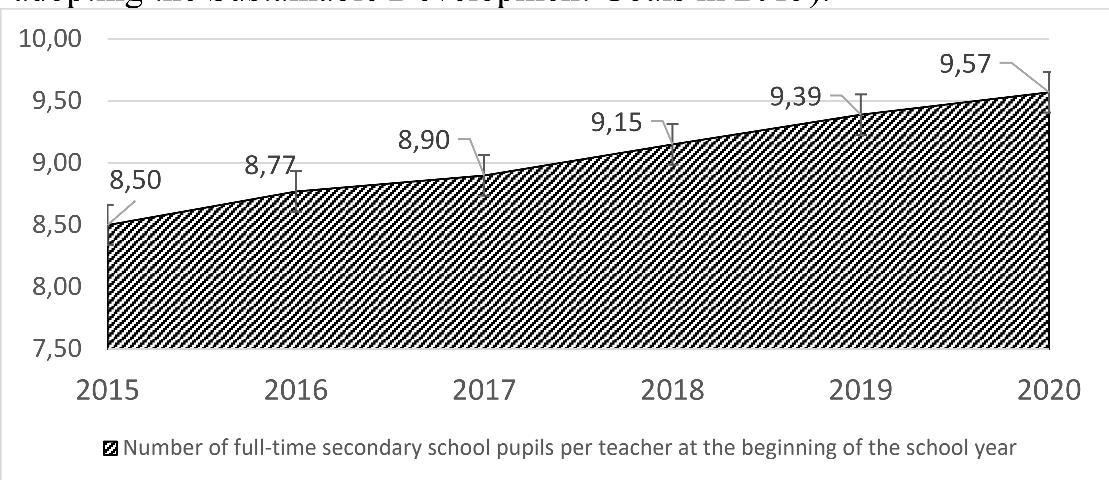


Figure 30. Number of full-time secondary school pupils per teacher at the beginning of the school year

Source: built by the authors based on Tsil 4. Yakisna osvita (2021)

It should be noted that the achievement for this indicator became possible due to school network optimization and the benchmark secondary education institutions establishment. However, sustainable development requires the effective operation of schools with the institutional, organizational and professional capacity to provide quality educational services. Let us further consider the statistical data on indicator 4.2.1 “Children up to 5 years old coverage by preschool education” (Figure 31).

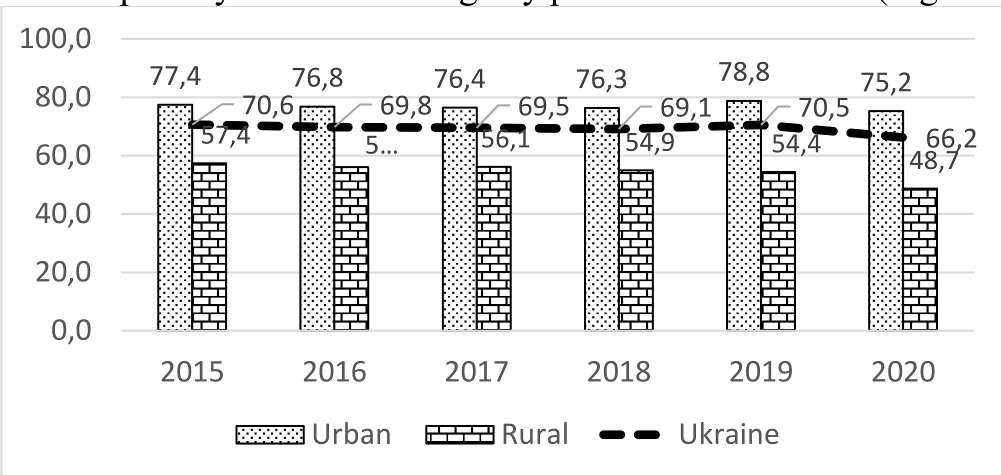


Figure 31. Children up to 5 years old coverage by preschool education
Source: built by the authors based on Tsil 4. Yakisna osvita (2021)

Figure 31. shows the advantage of urban settlements in providing preschool children with kindergarten. Due to a much smaller indicator of rural settlements, we get an all-Ukrainian indicator at the maximum level of 70.5%. In 2020, there is a decrease in this indicator both in the country as a whole and in terms of urban and rural areas. Undoubtedly, the primary reason for this is the pandemic year and the quarantine restrictions introduced distance learning. Just as many parents worked remotely, were on a forced vacation, or lost their jobs altogether - they had the opportunity to stay home with their children. Fear of possible coronavirus infection also prevented them from visiting crowded places and protecting children more carefully. Table 11. shows the benchmarks developed for the value of indicator 4.2.1 for the period from 2020 to 2030

Table 11

4.2.1 “Children up to 5 years old coverage by preschool education” indicator benchmark for 2020, 2025, and 2030, %

Indicator benchmark	**2020**	**2025**	**2030**
Indicators of the indicator 4.2.1 “Children up to 5 years old coverage by preschool education” for 2020, 2025, and 2030, %	80,0	90,0	95,0

Source: built by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020)

As shown in table 12 and figure 31, the benchmark was not reached; moreover, in 2020, we observe the maximum deviation of actual values from the benchmark.

Let us try to find the reason for such a deviation from the benchmark in changing the demographic situation in Ukraine. Table 12 shows the data on the number of children aged 2-4 years (age of kindergarten)

Table 12

Number of children of kindergarten age in 2015-2020, people

Age	2015	2016	2017	2018	2019	2020
2 years	487489	471450	462265	408532	394186	408388
3 years	470674	487356	471307	462137	408454	394117
4 years	465766	470530	487231	471199	462009	361612

Source: built by the authors based on Vikova struktura naselennya (2021)

One could assume that the provision of kindergartens for Ukrainian children is caused by demographic growth; however, Table 4 indicates a decrease in t children aged 2.3 and 4 years. Moreover, the situation looks threatening and needs more detailed analysis.

Figures 32-34 show the increase in the number of children of kindergarten age in the form of a histogram.

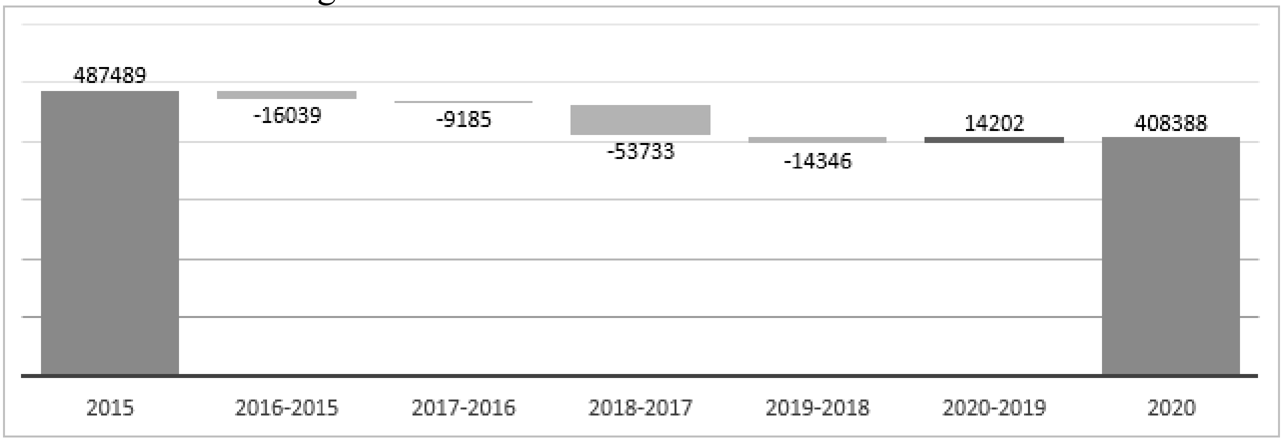


Figure 32. Change 2-years-aged children quantity, people
Source: built by the authors based on Vikova struktura naselennya (2021)

Considering the 2-year-old children quantity, we see a significant demographic decline in this age group of Ukrainians in 2018 and a slight increase in 2020. As these statistics apply to children born in 2016, we associate this situation with the seizure of the Ukrainian territorial part in 2015 and the start of hostilities. This has led to general concerns about the future, a peaceful area, and has helped postpone plans to expand the family.

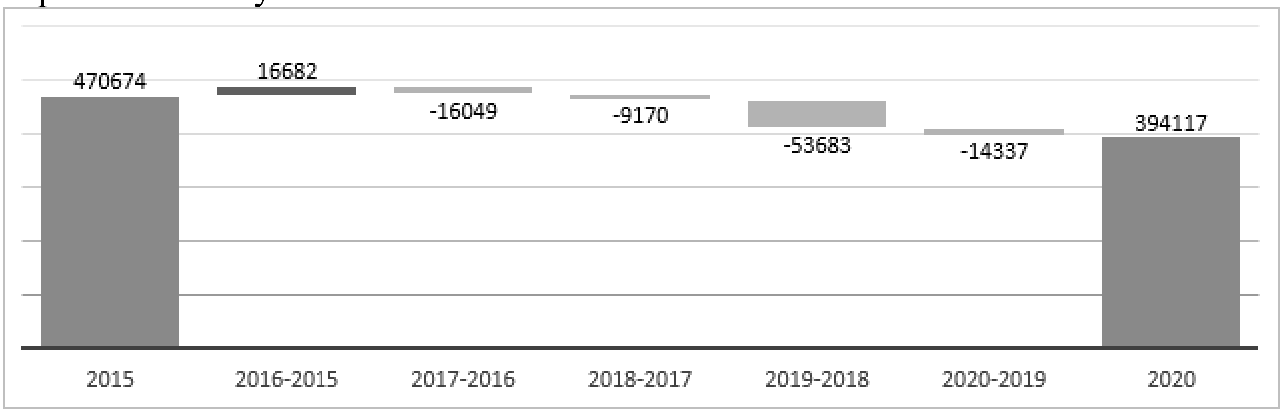


Figure 32. Change 3-years-aged children quantity, people
Source: built by the authors based on Vikova struktura naselennya (2021)

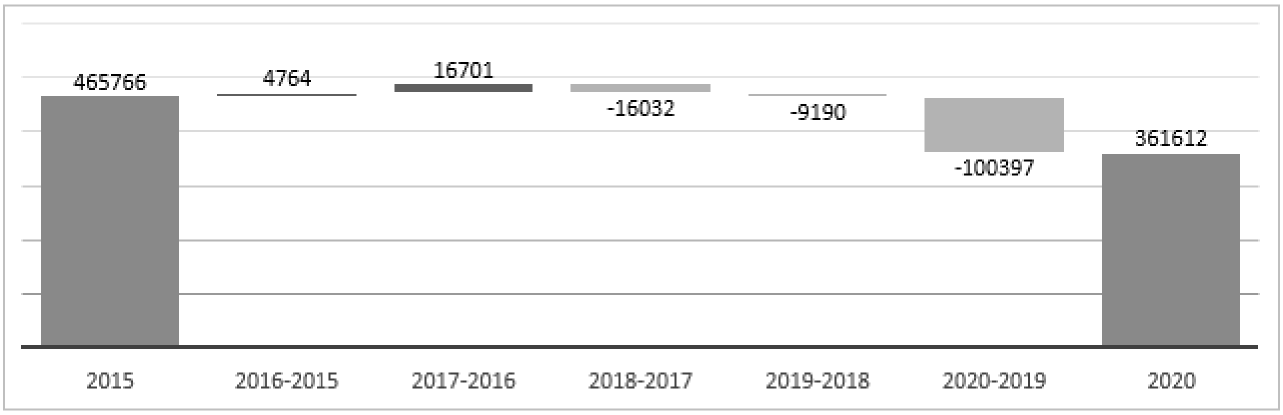


Figure 33. Change 4-years-aged children quantity, people
Source: built by the authors based on Vikova struktura naselennya (2021)

If we compare Figures 3.14 and 3.15, a shift in growth by one year can be seen in Figure 33. This is quite logical and reflects the population growth until 2015. In contrast to Figure 6, we do not observe growth in the number of children aged 3 and 4. Nevertheless, the fact that there is the first growth after the age of 2 indicates that providing kindergartens is becoming urgent and may deepen. Let us further investigate the indicator 4.3.1 “Entrants to vocational education institutions number ratio to the total number of places in education institutions (vocational and technical) education, financed from state and local budgets” implementation (Figure 34).

As Figure 34 shows, the benchmark for this indicator was fully reached in 2020. This has happened due, in particular, to the measures to optimize management and funding in the field of vocational education implementation; positive dynamics of indicators performance (state and regional order) for the training of workers in establishments of professional (vocational and technical) education restoration (Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020).

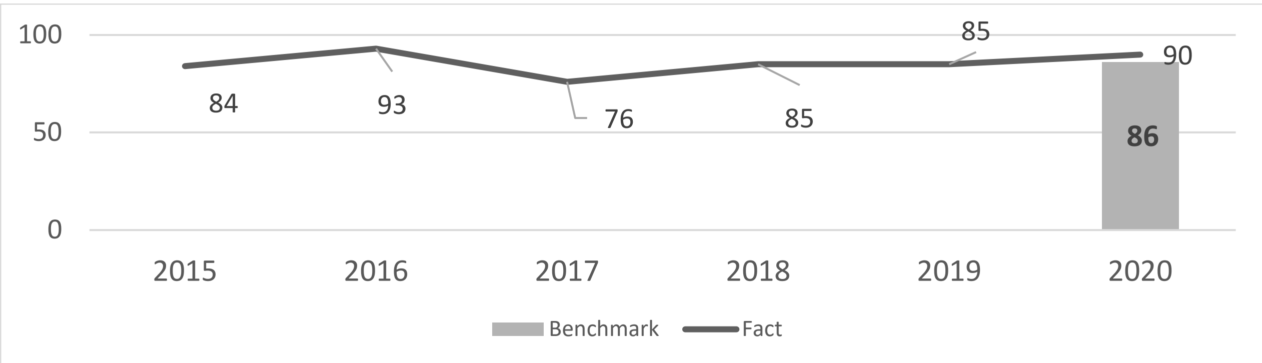


Figure 34. Entrants to vocational education institutions number ratio to the total number of places in education institutions (vocational and technical) education, financed from state and local budgets
Source: built by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) and Tsil 4. Yakisna osvita (2021)

In 2016, the first Ukrainian city joined the UNESCO Global Network of Learning Cities, and in 2017 Ukraine was represented by 4 cities - Melitopol, Pavlohrad, Nikopol, and Novoyavorivsk (Tsil 4. Yakisna osvita (2021). Driven by the principle of inclusion, learning cities advance policies and practices that foster sustainable development, notably through lifelong learning programs that promote equity, cohesion, and peace. When local governments empower communities and social actors to implement lifelong learning strategies and programs, they sponsor the achievement of the Sustainable Development Goals.

More specifically, a learning city is one that:

- effectively mobilizes resources in every sector to promote inclusive learning,
  from basic to higher education;
- revitalizes learning in families and communities;
- facilitates learning for and in the workplace;
- extends the use of modern learning technologies;
- enhances quality and excellence in learning;
- fosters a culture of learning throughout life.

In doing so, a learning city supports individual empowerment and social inclusion, economic development and cultural prosperity, and sustainable development (Learning cities: Drivers of inclusion and sustainability). Unfortunately, in 2020 Pavlohrad has stopped participating in this initiative (Members of the UNESCO Global Network of Learning Cities), but three more Ukrainian cities: Sumy, Lviv, and Poltava, instead expressed a desire to join (Sektor osvity pidtrymav doluchennya Cum, Lvova i Poltavy do hlobalnoyi merezhi yunesko mist, shcho navchayutsya (2020). The network supports its member cities by:

- promoting policy dialogue and peer learning;
- documenting effective strategies and best practices;
- fostering partnerships;
- providing capacity development;
- developing tools and instruments to design, implement and monitor learning cities' strategies (Learning cities: Drivers of inclusion and sustainability).

Thus, we hope that more Ukrainian cities will be able to use the benefits and opportunities of UNESCO effectively; and improve their education and sustainable development level. The following indicator 4.5.1 reflects population participation in formal and non-formal education and training (Table 13).

Table 13

The level of population participation in formal and informal types of learning and training in 2015-2019, %

Indicator	2015	2016	2017	2018	2019
The level of population participation in formal and non-formal learning and training	9,2	9,0	8,7	8,6	8,0
by age groups					
15-24 years	55,9	56,5	57,6	59,4	55,5
25-64 years	0,8	0,9	0,8	0,8	0,7
by gender					
women	8,8	8,4	8,1	8,0	7,5
men	9,8	9,6	9,3	9,4	8,7

Source: Tsil 4. Yakisna osvita (2021)

The benchmark for 2020 was set at 10% level. Unfortunately, the State Statistics Service has not yet published data for 2020 on this indicator. However, from Table 5 we can see a decrease in such activity in age and gender categories. This indicates the need to intensify work to increase the Ukrainian's interest and indifference to participate in such activities. Next, let us consider the indicator 4.5.2. "The population that has been using Internet services for the last 12 months share" (Table 14).

Table 14

The population that has been using Internet services for the last 12 months share, %

Indicator	2015	2016	2017	2018	2019
The population that has been using Internet services for the last 12 months share, %	**48,9**	**53,0**	**58,9**	**62,6**	**70,1**
including those, who lives					
in urban areas	58,4	62,7	67,7	70,1	77,4
inrural areas	30,3	34,1	41,7	47,8	55,9
including by age					
up to 15 years	36,6	43,8	50,2	53,2	64,8
15 - 17 years	86,7	86,0	91,1	89,2	97,7
18 - 24 years	81,9	84,7	89,6	93,5	95,8
25 - 35 years	75,9	80,4	87,6	89,3	94,4
36 - 59 years	52,2	57,1	65,1	70,7	79,7
60 - 74 years	18,7	22,3	26,5	33,0	39,5
75 years and older	4,2	5,1	6,1	7,7	12,9

Source: Tsil 4. Yakisna osvita (2021)

The benchmark for 2020 was the indicator's value at 59%, and for 2025 - 70%. Thus, as shown in Table 6, the average share of the population that reported using the Internet for the last 12 months in 2019 has reached the benchmark of 2025. However, the share of Internet users among the rural population and the retirement age remains low, which indicates the intensification of the efforts to improve the situation with access to the World Wide Web. The next indicator of achieving goal 4 "Quality education" is 4.6.1. "The share of men among teachers" (Figure 35).

In Ukraine, for years, the teaching profession was considered more "feminine", and low-paid teachers were not of interest among men who "should maintain the families and earn more". Teacher work, in contrast to, for example, work in the factory, is unregulated. It seems like more free time, but the teacher works almost constantly. In addition, women have many other responsibilities for cooking, raising children, cleaning, or gardening. It may sound funny or unfair, but it is true for many Ukrainian families. At the same time, attracting men to work in secondary education is mainly a task of changing attitudes towards gender equality and eliminating stereotypes. Figure 35 shows that the benchmark was not reached in 2020, but at least the declining dynamics of the share of men in school has changed with growth in the last year.

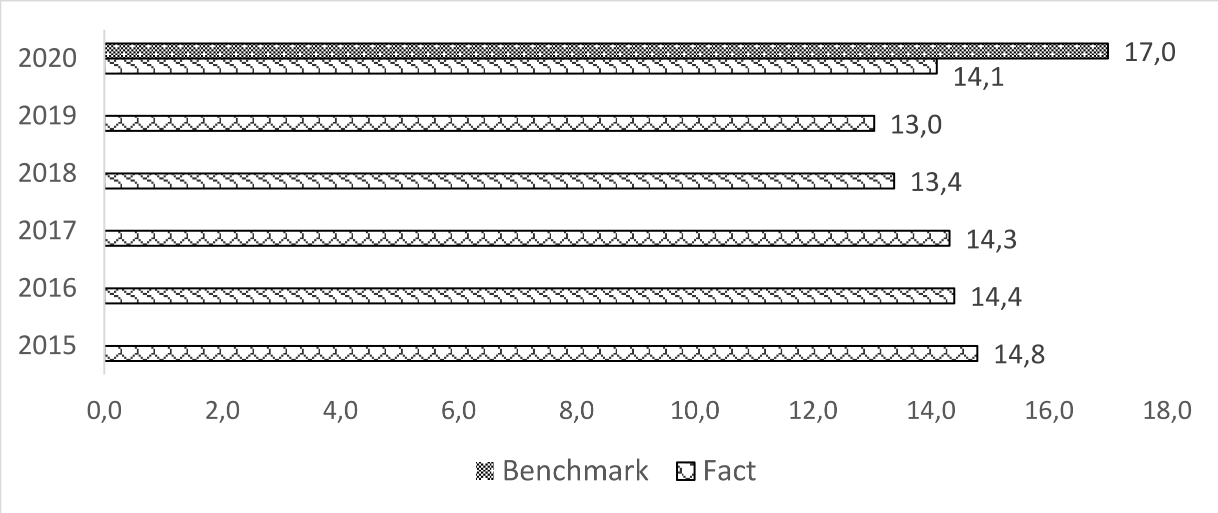


Figure 35. The share of men among teachers, %

Source: built by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) and Tsil 4. Yakisna osvita (2021)

Information on the indicator 4.7.1. "General secondary education institutions in rural areas with access to the Internet share" is shown in Figure 36.

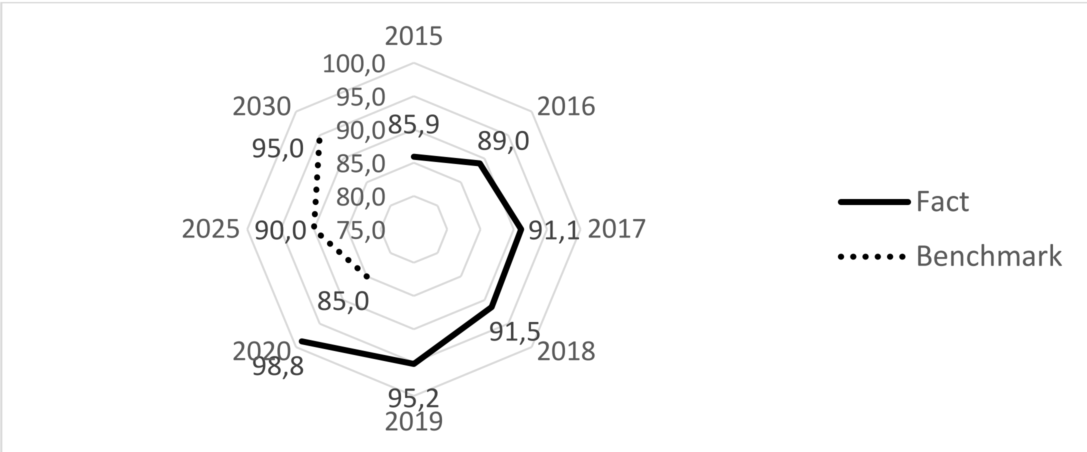


Figure 36. General secondary education institutions in rural areas that have access to the Internet share, %

Source: built by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) and Tsil 4. Yakisna osvita (2021)

Considering that in 2020 we managed to exceed the 2030 benchmark, we now have a reason to predict full coverage of secondary education institutions with access to the world wide web in the coming years. Data on the indicator 4.7.2. "General secondary schools in rural areas where computers are used in the educational process share" is shown in Figure 37.

The situation with this indicator is similar to the previous one. As of 2020, almost all schools have used computers in the educational process, reflecting full compliance with the benchmark. However, it should be noted that this indicator in current conditions no longer reflects the needs of informatization and is more commonplace.

The last indicator that allows us to assess implementing the task to create modern learning conditions in schools (including inclusive), based on innovative approaches - is 4.7.3 “Full-time general secondary education institutions with inclusive education share”.

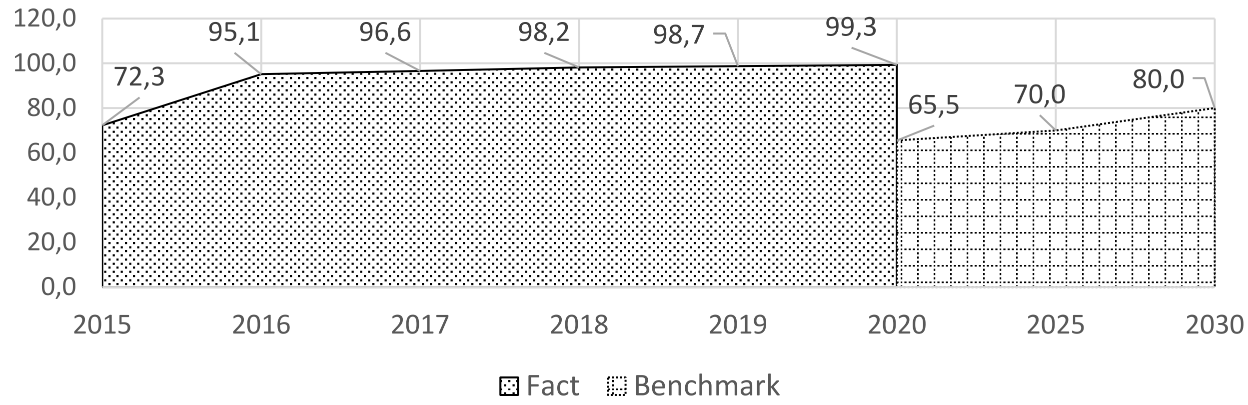


Figure 37. General secondary schools in rural areas where computers are used in the educational process share, %

Source: built by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) and Tsil 4. Yakisna osvita (2021)

The share of full-time general secondary education institutions in which inclusive education is organized is shown in Table 15.

Table 15

Full-time general secondary education institutions with inclusive education share, %

Indicator	2015	2016	2017	2018	2019	2020
Full-time general secondary education institutions with inclusive education share, %	**-**	**9,26**	**16,66**	**25,11**	**36,07**	**44,11**
school location type						
urban	-	-	-	-	49,50	57,40
rural	-	-	-	-	29,80	36,90

Source: Tsil 4. Yakisna osvita (2021)

Inclusive education is a relatively new phenomenon in the domestic secondary education system; however, it is necessary to consider the pupils’ needs equally to be in trend with the civilized world. Furthermore, if a child needs other, special learning conditions, they must be created to meet the general learning need. Thus, based on the statistical data analysis, the study of the Voluntary national review of Sustainable Development Goals and other sources, we have distributed the goals according to the probability of achievement (Table 16).

It should be noted that in comparison with the previous year, we observe a change in the category of indicator 4.6.1. “The share of men among teachers” from adverse to positive dynamics. Instead, on the contrary, the indicator 4.4.1. “Number of Ukrainian cities members of the UNESCO Global Network of Learning Cities” has shown a negative trend. However, according to this indicator, we forecast improvement (three Ukrainian cities have expressed a desire to join the initiative), so we have classified this indicator as a medium probability of achieving the goal.

Table 16

Achieving the tasks of the goal of sustainable development - quality education

Assess the probability of achieving the goal	Progress towards the goal	Indicators
The goal is difficult to achieve	Negative dynamics	4.2.1., 4.5.1
Low probability of achieving the goal	Weak positive dynamics that require a significant acceleration	4.4.1
Average probability of achieving the goal	Positive dynamics that need some acceleration	4.6.1
High probability of achieving the goal	Achieved or has a high achievement probability	4.1.2., 4.3.1., 4.5.2., 4.7.1., 4.7.2., 4.7.3

Source: supplemented by the authors based on Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) and Tsil 4. Yakisna osvita (2021)

To ensure the achievement of the Sustainable Development Goal №4 “Quality Education” it is necessary to (Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020):

- complete the implementation of the New Ukrainian School at the primary school level and ensure a quality transition to the implementation of the reform at the basic secondary education level;
- implement the provisions of the adopted Law of Ukraine “On Complete General Secondary Education”, which will increase the social status and wages of teachers, ensure appropriate conditions for their professional growth, increase the overall prestige of the teaching profession;
- complete the reform of the system of vocational education, take measures to promote it;
- develop a strategic vision of the role of vocational education in the development of the region with local authorities and local governments, to organize systematic work on vocational guidance of young people;
- promote the expansion of opportunities for quality and modern preschool education, raising the level of coverage of preschool children and the salaries of educators;
- adopt the National Strategy for the Development of Inclusive Education to 2030 and an action plan to it, which will consolidate the efforts of central and local authorities, educational institutions, communities, international and Ukrainian NGOs to develop inclusive education, create conditions for further deinstitutionalization of institutions education based on the child’s interests;
- ensure the overcoming of existing stereotypes and to develop civic competencies among students, in particular, those related to human rights, non-discrimination, democracy, the formation of high legal culture, and respect for the rule of law;
- accelerate the implementation of the education digitalization reform, particularly to provide schools with access to high-speed Internet, electronic textbooks, distance learning courses, curricula, manuals and

other educational resources. Such a resource will promote: distance education technologies development, which, in particular, are especially necessary during adverse situations of epidemiological nature, armed aggression, etc.; technological support of the New Ukrainian School; modern conditions for effective development of education creation; a single information network of resources and databases of the educational process creation; creating an interactive environment of educational institutions for teachers, students, parents, heads of institutions creation; data of the educational process accumulation and systematization; favorable environment for the development of electronic educational resources national production creation; e-learning development and formation of information and communication competence of participants of the educational process in Ukraine;

- provide funding for science in universities on a transparent basis to improve the overall quality of higher education, both in terms of teaching and scientific components;
- take measures to combat abuse in the education system; to form in the participants of the educational process a culture of academic and social integrity, intolerance of corruption in all its manifestations;
- research and innovation infrastructure development, the state of which ensures the conduct of basic and applied research at a high level and the creation and implementation (commercialization) by scientists the results of their research;
- introduce a mechanism for co-financing the creation of high-tech industries with the higher education institutions and research institutions participation;
- develop the digital services for the scientific, technical, and innovative activities implementation;
- ensure the provision of direct state support for innovation;
- determine the critical priority of educating conscious, responsible, and economically active young people who have a high level of vitality, independence and capacity, integrated into the country’s public life and adapted to the challenges of the modern world.

In the context of the Covid-19 pandemic in Ukraine deployment, it is crucial to develop distance technologies used in full-time and other forms of education.

REFERENCES

1. Longyu Shi, Linwei Han, Fengmei Yang and Lijie Gao (2019*)*. The Evolution of Sustainable Development Theory: Types, Goals, and Research Prospects. Retrieved from: https://www.mdpi.com/2071-1050/11/24/7158 . DOI: 10.3390/su11247158 (Last accessed: 01.08.2021)
2. *Technosphere Weighs 30 Trillion Tons (2017).* Retrieved from: https://nextnature.net/story/2017/technosphere-weighs-30-trillion-tons (Last accessed: 01.08.2021).

3. *Sustainable Development GOALS.* Retrieved from: https://www.ua.undp.org/content/ukraine/en/home/sustainable-development-goals.html (Last accessed: 02.08.2021)
4. *UNESCO. Literacy (2021).* Retrieved from: https://en.unesco.org/themes/literacy (Last accessed: 02.08.2021).
5. *VUCA world.* Retrieved from: https://www.vuca-world.org (Last accessed: 02.08.2021)
6. *Industry 4.0 and the fourth industrial revolution explained.* Retrieved from: https://www.i-scoop.eu/industry-4-0/ (Last accessed: 05.08.2021)
7. *Yak diyaty dali: Hromadi pro stalyy rozvytok* (2020) *[Act further: Sustainable development for community]*. Retrieved from: https://vumonline.ua/module-3/interv-yu-z-tomasom-borkmanom/ (Last accessed: 05.08.2021)
8. *Global Education Futures. Educational ecosystems for societal transformation (2021).* Retrieved from: https://futuref.org/educationfutures (Last accessed: 05.08.2021).
9. *The Global State of Digital 2021 (2021).* Retrieved from: https://www.hootsuite.com/resources/digital-trends (Last accessed: 06.08.2021).
10. *Why MOOCs Didn't Work, in 3 Data Points (2019).* Retrieved from: https://www.insidehighered.com/digital-learning/article/2019/01/16/study-offers-data-show-moocs-didnt-achieve-their-goals (Last accessed: 10.08.2021).
11. *The MOOC pivot (2019).* Retrieved from: https://science.sciencemag.org/content/363/6423/130?utm_source=e-Literate+Newsletter&utm_campaign=fd7c2d2185-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_deab6fbf84-fd7c2d2185-40282373 (Last accessed: 10.08.2021).
12. *Online Education for Sustainable Development (2020)*. Retrieved from: https://www.ua.undp.org/content/ukraine/en/home/sustainable-development-goals/online-courses-on-sustainable-development.html (Last accessed: 12.08.02021).
13. *By The Numbers: MOOC in 2020 (2020).* Retrieved from: https://www.classcentral.com/report/mooc-stats-2020/ (Last accessed: 10.08.2021).
14. *#BorderlessConversations Episode 4 | Recognising Digital Learning (2021).* Retrieved from: https://www.obhe.org/news/borderlessconversations-episode-4-or-recognising-digital-learning (Last accessed: 10.08.2021).
15. *Yak diyaty dali: Derzhavnym sluzhbovtsyam pro stalyy rozvytok (2020) [Act further: Sustainable development for civil servants]*. Retrieved from: https://courses.prometheus.org.ua/courses/course-v1:Prometheus+SDG101+2020_T2/about (Last accessed: 12.08.2021).

16.*Kharari ta Brehman otsinyly perekhid osvity v onlayn (2021) [Harari and Bregman summed up the transition of education to online]* Retrieved from: https://zn.ua/ukr/WORLD/kharari-ta-brehman-otsinili-perekhid-osviti-v-onlajn.html (Last accessed: 19.08.2021).
17.*Koronavirus ta osvita (2021) [Coronavirus and education]*. Retrieved from: https://www.ua.undp.org/content/ukraine/uk/home/library/democratic_governance/covid-and-education.html (Last accessed: 19.08.2021).
18.Botkin, J. W., Elmandjra, M., and Malitza, M. (1979). No Limits to Learning. Bridging the Human Gap: The Report to the Club of Rome. Retrieved from: https://www.coursenxt.com/book/no-limits-to-learning-bridging-the-human-gap-the-report-to-the-club-of-rome-by-j-w-botkin-m-elmandjra-and-m-malitza-auth-1st-edition-in-english-1979-in-pdf (Last accessed: 13.08.2021).
19.*GCNI. Sustainable Development Goals.* Retrieved from: https://globalcompact.org.ua/pro-nas/tsili-stijkogo-rozvytku/ (Last accessed: 13.08.2021).
20.*Sustainable development GOALS. Goal 12: Ensure sustainable consumption and production patterns.* Retrieved from: https://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (Last accessed: 13.08.2021).
21.*Statistical Review of World Energy (2020).* Retrieved from: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf (Last accessed: 14.08.2021).
22.*Global Environment Outlook 6 (2019).* Retrieved from: https://www.unep.org/resources/global-environment-outlook-6 (Last accessed: 18.08.2021).
23.*Human health in dire straits if urgent actions are not made to protect the environment, warns landmark UN report (2019).* Retrieved from: https://www.unep.org/news-and-stories/press-release/human-health-dire-straits-if-urgent-actions-are-not-made-protect (Last accessed: 18.08.2021).
24.*How does COVID-19 impact the environment? (2021)* Retrieved from: https://www.bdo.ua/en-gb/insights-1/information-materials/2021/how-does-covid-19-impact-the-environment (Last accessed: 19.08.2021).
25.*New rules to tackle 'wild west' of plastic waste dumped on poorer countries (2020).* Retrieved from: https://www.theguardian.com/environment/2020/dec/29/new-rules-to-tackle-wild-west-of-plastic-waste-dumped-on-poorer-countries (Last accessed: 19.08.2021).
26.*Zakon Ukrayiny "Pro osvitu" (2017) [Law of Ukraine "On Education"]*. Retrieved from: https://zakon.rada.gov.ua/laws/show/2145-19#Text (Last accessed: 21.08.2021).
27.*Naskrizni zmistovi liniyi [Through semantic lines]*. Retrieved from: https://mon.gov.ua/ua/osvita/zagalna-serednya-osvita/navchalni-programi/naskrizni-zmistovi-liniyi (Last accessed: 22.08.2021).

28. *Worldometers (2021).* Retrieved from: https://www.worldometers.info/uk/ (Last accessed: 28.08.2021).
29. *Every country has its own climate risks. What`s yours? (2021).* Retrieved from: https://www.nytimes.com/interactive/2021/01/28/opinion/climate-change-risks-by-country.html (Last accessed: 28.08.2021).
30. *International days.* Retrieved from: https://en.unesco.org/ commemorations/international-days (Last accessed: 30.08.2021).
31. *Institute of Education Content Modernization.* Retrieved from: http://en.imzo.gov.ua/about-us/ (Last accessed: 28.08.2021).
32. *Navchano-metodychnyy resurs dlya pedahohichnykh pratsivnykiv z realizatsiyi naskriznoyi zmistovoyi liniyi "Ekolohichna bezpeka ta stalyy rozvytok" (2020) [Educational and methodical resource for pedagogical workers on the implementation of the cross-cutting content line "Environmental safety and sustainable development"].* Retrieved from: http://www.e-comon.org.ua (Last accessed: 29.08.2021).
33. *Unikalni ta perspektyvni: innovatsiyni rozrobky ukrayintsiv, shcho nevdovzi pidkoryat ves svit (2021) [Unique and promising: innovative developments of Ukrainians who will soon conquer the whole world].* Retrieved from: https://innovation.24tv.ua/innovatsiyni-rozrobki-ukrayintsiv-shho-nevdovzi-ukrayina-novini_n1716576 (Last accessed: 29.08.2021).
34. *Zelenyy klas [Green class]* Retrieved from: https://www.ecolabel.org.ua/zelenyi-klas (Last accessed: 30.08.2021).
35. *UN Documents. Gathering a body of global agreements. Our Common Future, Chapter 2: Towards Sustainable Development.* Retrieved from: http://www.un-documents.net/ocf-02.htm (Last accessed: 15.07.2021).
36. *Sustainable Development.* Retrieved from: https://en.unesco.org/themes/ education-sustainable-development/what-is-esd/sd (Last accessed: 15.07.2021).
37. *17 Goals to Transform Our World.* Retrieved from: https://www.un.org/sustainabledevelopment/ (Last accessed: 15.07.2021).
38. *What are the Sustainable Development Goals?* Retrieved from: https://www.ua.undp.org/content/ukraine/en/home/sustainable-development-goals.html (Last accessed: 15.07.2021).
39. *Ukaz Prezydenta Ukrayiny "Pro Stratehiyu staloho rozvytku "Ukrayina – 2020" [Decree of the President of Ukraine "On the Strategy of Sustainable Development "Ukraine – 2020"], dated 12.01.2015 № 5/2015.* Retrieved from: https://zakon.rada.gov.ua/laws/show/5/2015#Text (Last accessed: 15.07.2021).
40. *Ukaz Prezydenta Ukrayiny "Pro Tsili staloho rozvytku Ukrayiny na period do 2030 roku" [Decree of the President of Ukraine "On the Sustainable Development Goals of Ukraine until 2030"] dated 30.09.2019 №* 722/2019. Retrieved from: *https://zakon.rada.gov.ua/laws/show/722/2019#Text* (Last accessed: 15.07.2021).
41. *Proekt Stratehiyi staloho rozvytku Ukrayiny do 2030 roku [*Strategy for sustainable development of Ukraine until 2030 draft*]* Retrieved from:

https://www.ua.undp.org/content/ukraine/en/home/library/sustainable-development-report/Sustainable-Dev-Strategy-for-Ukraine-by-2030.html (Last accessed: 15.07.2021).

42. *Goal 4: quality education.* Retrieved from: https://www.ua.undp.org/content/ukraine/en/home/sustainable-development-goals/goal-4-quality-education.html (Last accessed: 15.07.2021).
43. *Tsili staloho rozvytku Ukrayina. Dobrovilnyy natsionalnyy ohlyad (2020) [Sustainable Development Goals Ukraine. Voluntary National Review (2020)].* Retrieved from: https://www.me.gov.ua/Documents/Detail?lang=uk-UA&id =a0fc2a99-ada3-4a6d-b65b-cb542c3d5b77&title=DobrovilniiNatsionalnii OgliadSchodoTsileiStalogoRozvitkuVUkraini (Last accessed: 15.07.2021).
44. *Tsil 4. Yakisna osvita (2021) [Goal 4. Quality education (2021)]* Retrieved from: http://www.ukrstat.gov.ua/csr_prezent/ukr/st_rozv/metadata/04/ 04.htm (Last accessed: 15.07.2021).
45. *Vikova struktura naselennya (2021) [The population age structure (2021)]* Retrieved from: http://www.lv.ukrstat.gov.ua/dem/piramid/all.php (Last accessed: 15.07.2021).
46. *Learning cities: Drivers of inclusion and sustainability. Retrieved* from: https://uil.unesco.org/lifelong-learning/learning-cities/learning-cities-drivers-inclusion-and-sustainability (Last accessed: 15.07.2021).
47. *Members of the UNESCO Global Network of Learning Cities.* Retrieved from: https://uil.unesco.org/lifelong-learning/learning-cities/members (Last accessed: 15.07.2021).
48. *Sektor osvity pidtrymav doluchennya Cum, Lvova i Poltavy do hlobalnoyi merezhi yunesko mist, shcho navchayutsya (2020) [The education sector has supported the inclusion of Sumy, Lviv and Poltava in the UNESCO Global Network of Learning Cities (2020)].* Retrieved from: https://mon.gov.ua/ua/news/sektor-osviti-pidtrimav-doluchennya-sum-lvovu-ta-poltavi-do-globalnoyi -merezhi-yunesko-mist-sho-navchayutsya (Last accessed: 15.07.2021).

3.4. State policy foreign experience on the implementation of the education system for sustainable development

Podolchak Nazar
Sc.D., Professor (Economics),
Head of Administrative and Financial Management *Department*
Lviv Polytechnic National University
E-mail: Nazar.Y.Podolchak@lpnu.ua
ORCID: 0000-0002-0284-9601

Khim Mariia
Senior lecturer of Administrative and Financial Management Department
Lviv Polytechnic National University
E-mail:Mariya.K.Khim@lpnu.ua
ORCID: 0000-0002-3151-6435

Tsygylyk Nataliia
Ph.D (Technical),
assistant of Administrative and Financial Management Department
Lviv Polytechnic National University
E-mail: Natalia.V.Tsyhylyk@lpnu.ua
ORCID: 0000-0001-7038-380X

Today, the issue of sustainable development is one of the key in international cooperation among the world community. After all, it ensures the establishment of a balance between meeting the needs of society while conserving the Earth's resources and protecting the interests of future generations. The Covid-19 pandemic has affected all three components of Ukraine's sustainable development (Figure 1). By 2030, without well-established tactics to counter the pandemic at all levels, 17 sustainable development goals will not be achieved. In particular, the results of the literature sources' analysis show that the zone of greatest risk of inaccessibility includes eight goals:

- good health;
- quality education;
- gender equality;
- decent work and economic growth;
- reduction of inequality;
- innovations and infrastructure;
- sustainable development of cities and communities.

To improve the situation can education for sustainable development (ESD) - a type of education aimed at acquiring knowledge and skills that contribute to:

- formation of a new ecologically conscious society;
- formation of a new worldview, positions, values;

- development that is socially desirable, economically viable and environmentally balanced.

The world's leading countries, which have paid sufficient attention to this area of work, have managed to achieve high rates of sustainable development. That is why the issue of detailed study of cross-border experience in the implementation of the education system for sustainable development is extremely important.

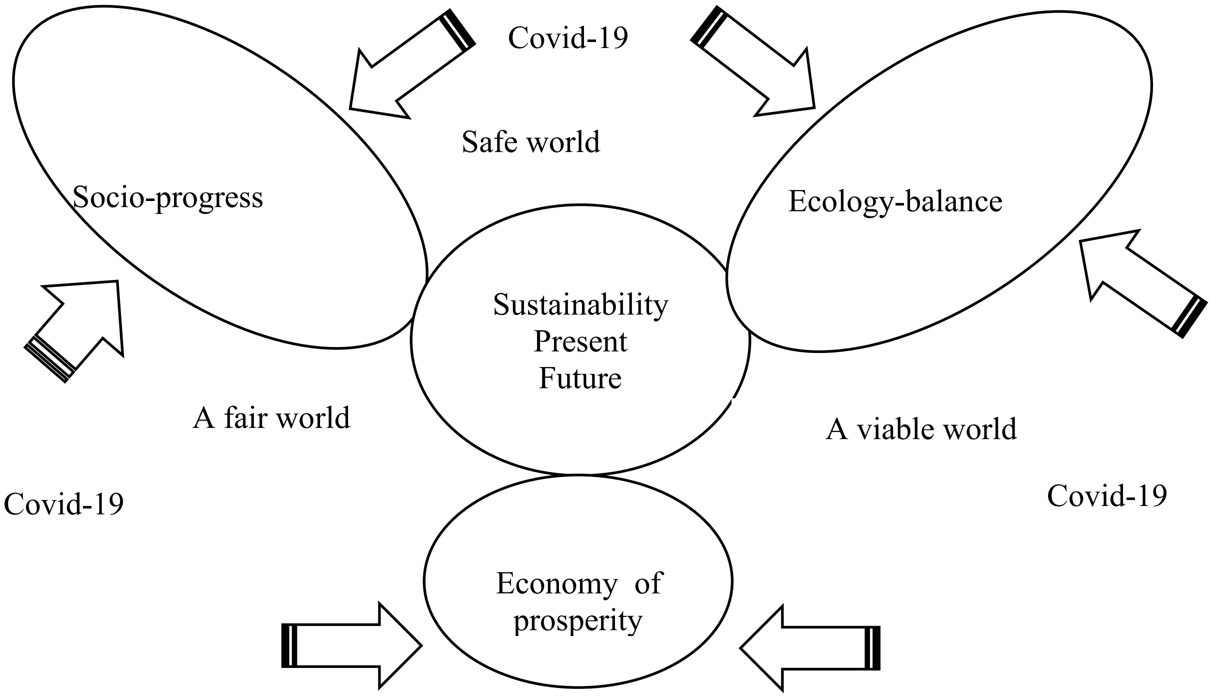


Fig. 38. The impact of Covid-19 on sustainable development
Source: developed by the authors

The education content components for sustainable development in the European Union' leading countries are: quality of life, social justice and equality; preservation of diversity: cultural, social and biological; relationship: in society, economy and environment; awareness of responsibility to future generations; civil position, rights and responsibilities of citizens; needs and rights of future generations to a quality life.

It should be noted that education for sustainable development is a key direction in the strategies of EU countries. After all, it is the key factor that contributes to the achievement of all sustainable development goals, and achieves its goal through the transformation of society. Figure 38 schematically shows the importance of education for sustainable development.

Education for sustainable development is based on the fundamental assumption that humanity must radically change the current course of economic, environmental and social development to ensure a healthy and quality life for present and future generations. In particular, in Sweden's "National Sustainable Development Strategy", the priority is to implement an action plan for education in the field of sustainable development, to support research and development projects in the fields of innovation, employment, social research, the environment, agriculture and spatial development planning [2].

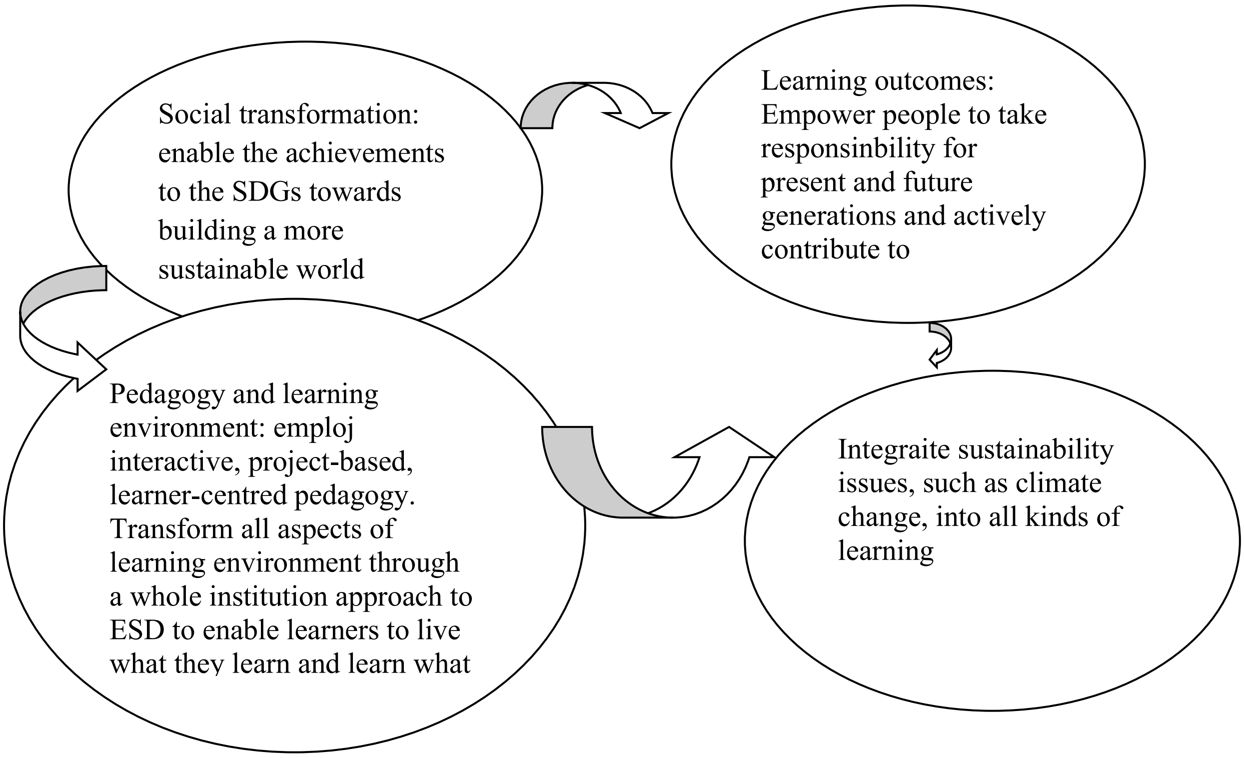


Fig. 38. The importance of education for sustainable development
Source: developed by the authors

In the strategy of the "State Action Program for Sustainable Development of the Netherlands" one of the priority areas is knowledge, which aims to develop a knowledge-based economy, stimulate innovation, integrate sustainable development into education, develop research on the relationship between knowledge, innovatio and sustainable development. In Germany's “Sustainable Development Strategy”, adopted in 2012, education is an important sustainable development indicator that needs to be expanded and stabilized at a high level by improving education systems and training. [1]. The German and Austrian federal governments have chosen an integrated approach to implementing the Agenda 2030 in order to integrate the sustainable development growth (SDG) into all policy and administration activities in an efficient, goal-oriented and responsible manner. Cooperation at all levels is crucial for sustainable development. Governments and civil societies, the private sector, the education sector and individuals must work together to make progress in reshaping the world.

Other EU Member States are also making every effort in this direction to ensure that the necessary conditions are in place for policies to be developed, evaluated and implemented on the basis of the best available knowledge and to be economically, socially and environmentally effective. The main impetus for the formation of a qualitatively new education system based on sustainable development is the reorientation of existing educational programs to a comprehensive study of social, environmental, economic issues, taking into account local, national and regional conditions, as well as the global context.

Developed countries (primarily EU countries) have committed themselves together with all UN member states to implement the "2030 Agenda for Sustainable

Development" ("Agenda for Sustainable Development until 2030") or - Agenda 2030 under called "Transforming our world" ("Transformation of our world"). According to the 17 Sustainable Development Goals (SDGs), the world community has specific areas to work to realize its ambitious vision of a peaceful, just, socially inclusive world that uses natural and human resources sustainably. The comprehensive changes in the economic, integrated and social world must ensure universal respect for human rights and opportunities, equality and self-determination.

The Organization for Economic Co-operation and Development (OECD) develops and monitors sustainability targets at the global level of experience. The complex program "The Future of Education and Skills Education 2030 - OECD" and "OECD Learning Framework 2030" has been created. The OECD Learning Framework 2030 offers the forms, visions and principles that underpin the future of the global education and science system. The learning framework was created for the OECD Learning Framework 2030 as a project of government representatives and a growing community of partners, including ideological leaders, experts, educational networks, heads of educational institutions, teachers, scientists, researchers, students, youth groups, parents and universities (and other forms of free economic zones, organizations and social partners) [2].

It is worth noting the importance of UNESCO's work in implementing education for sustainable development. This organization is responsible for the overall management, coordination and implementation of education for sustainable development. UNESCO's work on the ESD focuses on five priority areas (Table 17).

Table 17

UNESCO's work on the ESD

Action areas	Description
Advanced policy	Policy support is equally important for the formal, non-formal and informal sectors, as well as for the creation of synergies between the sectors. Moreover, advancing policies that support ESD does not only concern the education sector, but all sectors involved in sustainable development.
Transforming learning environments	To encourage learners to become change agents who have the knowledge, means, willingness and courage to take transformative action for sustainable development, learning institutions need, themselves, to be transformed. This whole-institution approach to ESD calls for learning environments where learners learn what they live and live what they learn.
Building capacities for educators	In order to guide and empower learners, educators themselves need to be empowered and equipped with the knowledge, skills, values and behaviours that are required for this transition. This includes understanding key aspects of each of the 17 SDGs and their interlinkages, as well as understanding how transformative actions occur and which gender transformative pedagogical approaches can best bring them about.
Empowering and mobilizing youth	Empowering and mobilizing young people of all genders, therefore, is a central part of ESD implementation.

Source: Developed and systematized by the authors based on the source [3]

Leading Education 2030 is also an updated holistic and transformative educational program on the UNESCO agenda, which aims to contribute to the achievement of all its goals of sustainable development. UNESCO understands education as comprehensive and necessary for the development of democracy and human rights, as well as the strengthening of global citizenship and sustainable development. It should be noted that UNESCO monitors and evaluates progress on the Sustainable Development Goal Indicator, in particular the extent to which civic and sustainable education are taken into account in: national educational policy; training programs; pedagogical education; assessment of students [4].

In 2007, the UN Steering Committee firstly performed national implementation reporting cycle - a unique exercise to collect indepth information about the successes and challenges of educating for sustainable development. The UNECE Expert Group of Indicators developed a reporting mechanism, which aims at to enable countries of the region to learn from each other and advance in the area of ESD. Such a report is published once every 2 years to provide a mirror which can help countries and regions in moving forward. Table 18 illustrates the comparison of Germany as the reference country of the education system for sustainable development and Ukraine according to the main indicators. Germany was chosen for comparison as the leading EU country.

Table 18

The main ESD indicators (2018) of Ukraine and Germany

Indicator	Name	Germany	Ukraine
1.1	Prerequisite measures are taken to support the promotion of ESD	Completed	Developing
1.2	Policy, regulatory and operational frameworks support the promotion of ESD	Developing	Inprogress
1.3	National policies support synergies between processes related to SD and ESD	Developing	Inprogress
2.1	SD key themes are addressed informal education	Developing	Inprogress
2.2	Strategies to implement ESD are clearly identified	Completed	Inprogress
2.3	Awhole-institution approach to ESD/SD is promoted	Developing	Developing
2.4	ESD is addressed by quality assessment/enhancement systems	Developing	Developing
2.5	ESDmethodsandinstrumentsfornon-formaland informal learning are in place to assess changes in knowledge,attitude and practice	Developing	Inprogress
2.6	ESD implementation is amulti-stakeholder process	Inprogress	Inprogress
3.1	ESD is included in the training of educators	Completed	Inprogress
3.2	Opportunities exist for educators to cooperate on ESD	Developing	Inprogress
4.1	Teachingtoolsand materials for ESD are produced	Developing	Inprogress
4.2	Quality control mechanisms for teaching tools and materials for ESD exist	Inprogress	Inprogress
4.3	Teaching too lsand materials for ESD are accessible	Developing	Inprogress
5.1	Researchon ESD is promoted	Developing	Developing
5.2	Development of ESD is promoted	Developing	Inprogress
5.3	Dissemination of research results on ESD is promoted	Developing	Developing
6.1	International cooperation on ESD is strengthened within the ECE region andbeyond	Completed	Developing

Source: Developed and systematized by the authors based on the source [5]

In Germany indicators “measures are taken to support the promotion of ESD”, “strategies to implement ESD are clearly identified”, “ESD is included in the training of educators”, “international cooperation on ESD is strengthened within the ESD region and beyond” are completed, while in Ukraine they are only developing or in progress. In general, Germany is actively developing in the field of education for sustainable development. Ukraine is also moving in this direction, but by most indicators it is a novice country.

The consistent transition of Ukraine to sustainable development, as well as the entire world community, is taking place in accordance with the recommendations and principles set out in the documents of the United Nations Conference on the Environment (UNCED). In March 2005, Ukraine joined the 55 countries that signed the UN Strategy for Education for Sustainable Development. During the 190th session, the UNESCO Executive Board noted that the priority is to determine a further work program for the period after 2014 (completion of the Decade of Education for Sustainable Development), in which Ukrainian scientists, environmentalists, educators, statesmen and the public were actively involved.

A significant step towards the sustainable development of education was the adoption of the National Strategy for Education in Ukraine until 2021, which defines the greening of education, and among the promising tasks - updating the goals and content of education based on a competent approach and principles of sustainable development. Also, in 2011 the Law of Ukraine “On Basic Principles (Strategy) of the State Environmental Policy of Ukraine until 2020” was adopted and the “National Action Plan for Environmental Protection for 2011-2015” was approved, which, in particular, provides for the development and implementation of the Strategy of Environmental Education for Sustainable Development of Ukrainian Society and Economy of Ukraine [6].

In the draft Law "On the Strategy for Sustainable Development of Ukraine until 2030", ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all is one of the main strategic goals of sustainable development [7]. Given the extreme importance of environmental education and sustainable development, the need to achieve strategic goals and objectives defined by the Law of Ukraine "On Basic Principles (Strategy) of State Environmental Policy of Ukraine until 2020" and the UNECE Strategy for Education sustainable development. The main activities of the process "Education in the interests of sustainable development in Ukraine" include:

• development of a national legislative and methodological framework for the introduction of the education for sustainable development basics through the preparation of the education for sustainable development concept, the national action plan for implementing the education strategy for sustainable development, the establishment and operation of the Intersectoral Working Group on Environmental Education sustainable development;

• expanding opportunities for capacity building of teachers and students at the local level by pilot implementation of education elements in the interests of sustainable development;

• creation of a partner network, including public organizations working to implement education in the interests of sustainable development in Ukraine;

• coverage and dissemination of Ukraine experience results and exchange at the international level, participation in the preparation of proposals for the work program for the period after 2021 (after the Decade of Education for Sustainable Development, defined by UNESCO) [6].

In order to confidently stand next to the world's leading nations and take a worthy place in the world community, Ukraine must use its education system not only to train qualified professionals, but also to form socially mature, responsible, cultural and spiritually mature citizens. How to restructure the post-Soviet education system into a national Ukrainian one, how to train specialists, what model of education to use in the learning process - these and other issues are extremely relevant for philosophers, teachers and statesmen. To fundamentally address this issue, it is necessary to pay sufficient attention to the development of emotional intelligence. First of all - the leaders in the field of public administration and administration. After all, it depends on them the effectiveness of solving tasks, which, in turn, depend on the right team and the ability to build interaction to achieve the goal. This is especially true now, in the 21st century, when Generation Z is gradually replacing Generation X, and the level of EQ is becoming equivalent in importance to IQ. Beside this with emotional intelligence all people have the capacity to focus on what’s most important. Emotions can contribute to challenges, but with EQ, they become resources to empower change, fuel collaboration and spark the innovation needed to make the aim true. In this case, if the level of IQ depends on human genetics, then EQ is learned throughout life and depends on the influence of a number of factors. According to the latest research by scientists, EQ in modern society is much more important than IQ.

Given the importance of the level of emotional intelligence to achieve the goals of sustainable development, features for the implementation of education State of the Heart research with metod Six Seconds Emotional Intelligence Assessment –SEI (the world’s largest study of emotional intelligence. It has been implemented since 2011year and studies people in 150 countries) and identifies three competencies that are most closely linked to achieving positive results today:

PNG = Pursue Noble Goals (putting purpose into action)

EO = Exercise Optimism (creating possibilities)

EIM = Engage Intrinsic Motivation (fueling ourselves from the inside)

It should be noted, that uses a randomized sample balanced by geography, gender, and age. SEI is best-in-class because of the blend of robust psychometrics, real-world practicality for a wide range of needs, and global relevance.

The main tools for implementing education for sustainable development should be:

- dialogue: establishing mutual understanding and constant dialogue between teachers and students;

- training: development of new knowledge, skills and abilities to encourage the practice of sustainability in various spheres of human life;

- information: access to information on sustainable development and the environment;

- marketing: changes in everyone's behavior in favor of sustainability.

Areas of educational activity:

- introduction of integrative courses and lessons that promote the development of systems thinking;
- introduction of courses on the development of critical thinking and argumentative discourse, appropriate information culture;
- courses on the development of environmental culture, taking into account modern socio-cultural needs (formation of appropriate consumer culture, health skills);
- humanocentric courses (development of moral culture of the individual with the involvement of the idea of a responsible attitude to life);
- socio-strategic courses (disclosure of major trends and threats to social development);
- courses aimed at developing the integration culture of the individual - ethics of tolerance, gender equality, multiculturalism;
- courses aimed at developing the civic and legal culture of the individual.

It should be noted that the government has a great influence on the implementation of education for sustainable development. Characterizing the changes in developed countries over the last twenty years, in particular, in Germany, it is clear that they are associated with a dynamic increase in the impact of local and regional processes on development in general. In modern Ukraine, this influence is transformed into a process of decentralization of power by increasing the role of local authorities at different territorial levels. For more effective implementation of education on sustainable development and other areas of global goals, there is a constant search for new models of public administration, which include both horizontal coordination of central executive bodies (sectoral policies) and vertical - between central and local authorities (multilevel governance).

According to the practice of OECD countries, the most effective way to resolve conflicting cross-sectoral problems, including the introduction of education for sustainable development, is to entrust coordination powers to the government. The key task of the ministry responsible for sustainable development should remain the prior coordination of positions between central bodies, as well as close coordination in the implementation of public policy at the regional and local levels. In some EU countries, the activities of special institutions are directed directly by the heads of ministries. That is why such a model should be chosen for Ukraine. In addition, special attention should be paid to improving the emotional intelligence of civil servants, because their effective work is one of the main components of a successful public policy. This is especially important in a Covid-19 pandemic.

As recovery efforts have intensified recently, there is a unique opportunity to rethink some of the business models used by educational institutions and possibly review some activities to make educational institutions more sustainable.

Educational institutions are recommended to:

1. Prepare and implement organizational strategies based on existing knowledge on how to fight the virus within the concept of sustainable development.

The priority is to prevent the spread of the virus. These methods will be to reduce consumption, reduce environmental impact and reduce costs.

2. Use information about the many socio-economic consequences of COVID-19 for their training courses, explain it, justify it, discuss it with students.

3. Investigate the possibilities of expanding the range of interdisciplinary research on the relationship between COVID-19 and sustainable development. The transformative power of research can help both to bridge significant knowledge gaps and to obtain external funding for interdisciplinary projects, which, among other things, can ease the pressure on university budgets, many of which are no longer able to provide large-scale funding for internal projects.

4. Consider ways to reduce carbon emissions in higher education institutions, using environmentally friendly means, to avoid problems in educational activities and international cooperation.

To mitigate the effects of the pandemic, as well as to create a more resilient system that can withstand future crises, the following measures for Ukraine and other countries are recommended:

1. Implementation of programs to restore the educational process. Governments must ensure that students who are lagging behind receive the necessary support to achieve their expected learning goals. Accelerated learning or tutoring programs can help address gaps.

2. Protection of educational budgets. To help the most vulnerable learners, governments need to prioritize and direct most of their funding and resources to support for educational institutions. In the event of a budget cut, wealthy families will be able to continue to pay for educational services, such as tutoring. For example, the United Kingdom has announced the creation of a £ 1 billion student learning fund, and a National Tutoring Program with a budget of £ 76 million.

3. Preparation for future upheavals, by restoring the education system on the principle of "better than it was". We must not only rebuild the system after a pandemic, but also use this experience to be better prepared for future crises. Educational institutions should be better prepared for a smooth transition from full-time to distance learning if it will be necessary. In addition, teachers need to be better prepared to manage a wide range of IT devices in the event of school closures in the future.

At the same time, it is important to build a future education system that can better use blended learning models and provide more individualized approaches to teaching [8].

REFERENCES:

1. Omarov Sh. (2014). Kontseptsiia staloho rozvytku v zakonodavstvi Ukrainy ta krain svitu i praktyka yii vprovadzhennia [The concept of sustainable development in the legislation of Ukraine and the world and the practice of its implementation]. *Businessinform,* 12, 85-95

Kyzym M. et al. (2010). Osnovy staloho rozvytku Kharkivskoi oblasti do 2020 roku [Principles of sustainable development of the Kharkiv region by 2020]: *monograph*. Kharkiv: INZhEK, 268 p.

2. Zinchenko V. (2020). Instytualizatsiia vyshchoi osvity i nauky v stratehii stiikoho suspilnoho rozvytku: hlobalnyi ta yevropeiskyi rivni [Institutionalization of higher education and science in the strategy of sustainable social development: global and European levels]. *International Scientific Journal of Universities and Leadership,* 1 (9), 32-61. DOI: 0.31874/2520-6702-2020-9-1-32-61

3. UNESCO (2020). *Global Action Programme on Education for Sustainable Development (2015-2019.* Retrived from: https://en.unesco.org/gap/priority-action-areas (Last accessed:12.09.2021)

4. UNESCO (2021). *What UNESCO does on Education for Sustainable Development.* Retrived from: https://en.unesco.org/themes/education-sustainable-development/what-UNESCO-does (Last accessed:15.09.2021)

5. UNESE (2018). *National Implementation Reports.* Retrived from: https://unece.org/national-implementation-reports (Last accessed:9.09.2021)

6. *Osvita v interesakh staloho rozvytku v Ukraini (2020). Mizhnarodnyi protses «Osvita v interesakh staloho rozvytku»* [International process "Education for Sustainable Development"]. Retrived from: http://ecoosvita.org.ua/storinka/pro-nas (Last accessed:16.09.2021)

7. Ligazakon (2018). Zakon Ukrainy *"Pro Stratehiiu staloho rozvytku Ukrainy do 2030 roku" №9015 vid 07.08.2018* [Law of Ukraine "On the Strategy of Sustainable Development of Ukraine until 2030" №9015 from 7.08.2018]. Retrived from: https://ips.ligazakon.net/document/JH6YF00A?an=517 (Last accessed:15.09.2021)

8. The world bank (2021). *The Impact of COVID-19 on Education – Recommendations and Opportunities for Ukraine.* Retrived from: https://www.worldbank.org/en/news/opinion/2021/04/02/the-impact-of-covid-19-on-education-recommendations-and-opportunities-for-ukraine (Last accessed: 10.09.2021)

IV. GREEN SCENARIOS OF DIGITALIZATION OF AGRICULTURE

4.1. Digital environmental monitoring

Olha Shulha
Doctor of Economics, Associate Professor
Associate Professor of the Department of management and marketing
State University of Intelligent Technologies and
Telecommunications Kyiv, Ukraine
E-mail: shulga_olga_a@ukr.net
ORCID ID 0000-0002-3230-3124

Ecological monitoring is an assessment of the impact of various factors on the environment using modern space navigation systems using geoteching and geocaching. Ecological observational geotagging in environmental monitoring is a modern technology of cognition of the natural environment, aimed at studying the state of ecological and geographical heritage. The task of this specific type of monitoring helps to solve a satellite GPS-navigator that receives radio signals from artificial satellites of the Earth. According to these signals, the user is given the coordinates of the point where he is, speed, distance to a given object, altitude, path angle, trajectory (azimuth), distance traveled, astronomical data and much more.

Geocaching involves finding unique natural exclusives or solving natural anomalies related to geographical coordinates. Ecological-observational geocaching is introduced in regular reconnaissance[1] expeditions and can be used to teach modern cartographic and geodetic technologies.

An important factor in the effectiveness of environmental monitoring is the introduction of satellite navigation and mapping technologies. But the problem is that the declarative introduction of a cartographic GPS method for observational reconnaissance sometimes leads to a formalization, which is to reject the capabilities of smart systems in the environment. Therefore, an innovative methodology of observational environmental monitoring - satellite geotagging - is appropriate.

Ecological-observational geotagging, as the latest methodology, is aimed at the formation and improvement (optimization) of the observational monitoring system: geoinformation systems, including the use of GPS-navigator and smart gadgets; technological interaction in the process of creating a general program of environmental monitoring, work with the latest information and communication technologies of geoinformatics, geography, local lore, recreation. In the course of ecological monitoring of this technology, the territorial and functional components of the environment are outlined and determined.

Development is currently underway innovation tools[2] of digital reality of the environment. The concept of innovation tools of digital reality of the environment is

---

[1] Reconnaissance is geospatial reconnaissance to identify new natural and man-made objects that cannot be found or identified on maps or aerospace images.

[2] Innovation tools – a set of devices and software that have no analogues.

based on already tested theoretical aspects of ecological and landscape transformation of natural-territorial complex of scale range 1:50 000 - 1:100 000. The corresponding measure of monitoring territorial «environmental safety» is confirmed by aerospace survey and remote sensing of the Earth. And not only by them. It is known that geosystem landscape mapping in determining the geophysical sources of disturbers of laterality (stability) of the landscape is carried out on a priority scale of 1:64 000. The corresponding lack of safety in organizing travel, especially non-group, amateurs cause potential natural and man-made hazards of territories, biological and sanitary-epidemiological hazards. But the factor of geotransmission of hazardous substances in seaports, airports, postal and transport transportation accompanying tourist transfer is not taken into account.

Consider the approbation algorithm of innovation tools of digital reality of the environment with the help of crowdsourcing programs of spatial visualization. The information-analytical core of the functioning of geointelligent systems of ecological decision-making is the technology of forming databases of the geoinformation system, which accumulates data of specialized observational reconnaissance on the components of the infrastructure of ecological-geographical observations.

There are two options for instrumentation of the relevant geodetic surveys. The first option - on the basis of certain logistics: graphics station-geoserver for centralized geoprocessing data F2D64AV HPz640 + HP Z27n (K7C09A4); workstation of the administrator of the geoinformation system of the cadastre PZF F5G73AV Z440 + z24n K7B99A4; set for aerial photogeodesic works; Inspire 2 quadcopter, ZENMUSE X4S camcorder, battery for Inspire 2 Part 17TB50 Intelligent Flight Battery quadcopter, Lenovo tablet. The second option is Android applications for smartphones with open access to satellite signals (Geodezist, Fields Area Measure, Compass). You must adjust and compare the gadget before you can use it.

Astronomical and geodetic programs have the technological ability to determine the magnetic declination, accuracy up to six decimal places, true azimuth, and so on. Appropriate programs make it possible to determine the location of navigation stars in the celestial sphere, which provides convenience when navigating the terrain offline in force majeure. For the needs of ecological tourism, the Android application «Compass» transmits data of the Sun and the Moon in spatial mode, which provides perceptual ideas about their location in dense clouds and other dangerous meteorological phenomena.

Chamber-appropriate field work, but with less accuracy, can be performed using coordinate systems of geoportals. The most used for these purposes is Google Earth, where it is possible to take the coordinates and indicate the monitoring point on the map with the additional ability to select a symbol from the proposed or specify the author's symbol. According to the appropriate set of polygonal points, it is possible to build a terrain profile, remove any metrics, apply thematic maps or graphic images of the terrain of different time characteristics on the base layer. The set of collected and generated geospatial data is the basis for the compilation of environmental monitoring maps, atlases and plans, primarily interactive.

Static maps of the digital terrain model are placed in the geographic information system Golden SoftWare Surfer 11. The spatial representation of the geographical distribution of statistical data can be demonstrated in the cartographic editor of geographic information modeling QuickMap (Qmap). In addition, it is advisable to use the vector graphics program Paint.EXE to create a contour map-basis for further transformation in the Digital QuickMap environment into a full-fledged base map. Important in designing an ecological map is the design and sketching of the layout of the cartographic model. Convenient and proven programs for relevant work are: Adobe Illustrator or the simplest Windows Paint, whose graphics capabilities do not reduce the quality of cartographic and geographic information products and models. Appropriate work of graphic editors is the basis for designing simulation interpretation GIF-models. They can be done in any relevant online service on the Internet, which will provide an idea of simulation and simulation of the realism of the environment over time in the process of forecasting or retrospective analysis.

The most modern trend of cartographic production of geoinformation models of ecological, nature protection and resource-saving thematic content is the design of interactive crowdsourcing maps in the environment of public geoportals GoogleMap, OpenStreetMap and GoogleEarth. To create an interactive GoogleMap, you need to import the data of the Geodezist program, select the suggested or selected library of symbols for them and form the subject in the map legend. The map model can be operated open or for business use and the corresponding *kmz file can be downloaded for archiving and storage. When the geotagging function is activated on the smartphone, it is possible to automatically photograph the object of the terrain on an observational model of the environment. As a result of creation of the corresponding atlas scenarios on them it is necessary to carry out cartographic works and geoinformation manipulation of data, both geographical content, and materials of remote sensing of the Earth. This makes it possible to create models for the needs of environmental monitoring and organization of ecological and tourist trips.

Environmental quality management is implemented by conducting permanent environmental monitoring to identify sources of anthropogenic impact on the environment. Territorially relevant monitoring to assess the risks of man-made load is carried out at the locations of industrial enterprises, large urban areas affected by vehicle pollution along highways, and in areas of natural and man-made emergencies. Aerospace technologies and geographic information systems are used to obtain up-to-date information on the state of environmental transformation under the influence of anthropogenic factors, to identify sources that form risk factors and to formulate recommendations for their prevention and overcoming. Processing and modeling is implemented in the created simulation models in the environment of expert geointelligent systems of ecological decision-making, such as geointelligent system Golden Software Surfer and QMap.

The core of geointelligent environmental decision-making systems are satellite systems for remote sensing of the Earth. The main tasks of geointelligent systems of precise management of ecological monitoring for operative definition of risks of anthropogenic influence are input, processing, storage and output of geoinformation according to inquiries and requirements of management system of ecological monitoring, various cartographic data on a state of environment, geodata on dynamic mobile, industrial and industrial objects that affect the general state of the environment and the medical and geographical situation on the territory of local united territorial communities. The methodology of construction, construction and design of models, methods and means of formation of dynamic scenarios for ecological geographic information systems of real time is developed. Moving objects of space, air and ground basis are used to increase the reliability of perception and presentation of geodata about the environment.

A necessary step in the management of environmental quality monitoring is engineering and technical reconnaissance at the relevant points of environmental observation by landmarks[3], including field research with visits to problem sites and areas. The relevant segment of research is provided by geodetic instruments: digital total stations, laser scanners, satellite observation kits to record dynamic (transient) phenomena and processes, such as ammonia spillage or deformation of engineering structures and structures destroyed by natural disasters or natural disasters. Even those caused by factors such as fires, arson, and terrorism at industrial sites.

The emergence of a local emergency is a consequence of the urgent coordination of sources of industrial and anthropogenic pollution. This requires the use of gadget GPS software, namely Android applications: GPS Status & ToolBox Professional and GeoDesist. This allows iterative prediction of geospatial aspects of the distribution of, for example, potent toxic substances. By means of command communication means to inform the population about carrying out operative emergency measures on evacuation of the territorial community in the corresponding places of defeat.

With the introduction of environmental quality monitoring in the management system and operational identification of risks of man-made impact with the help of unmanned aerial vehicles as part of aerospace systems, the degree of operational awareness of state and municipal institutions and relevant specialized emergency rescue teams increases. Technological functionality of transmission of the corresponding streaming operative geoinformation and its transformation into digital object and area symbols on cartographic services of the Internet - geoportals, electronic orthophotos creates preconditions for qualitative prevention (control) of an emergency situation. This potentially reduces human and financial losses. The geointelligent core of such an environmental monitoring management system for the rapid identification of anthropogenic impacts is specialized geointelligent systems that allow you to display operational geoinformation about the current environmental situation on a digital environmental map without delay.

The technology of environmental monitoring management to determine the risks of anthropogenic impact is implemented in combination with geointelligent systems and GPS. This allows for enhanced control over operations to prevent and eliminate their consequences, to monitor changes in the situation over time in each problem area or water area.

---

[3] A landmark is an anthropogenic or natural geospatially coordinated object or complex that dominates a natural or man-made landscape.

Aerospace technologies and systems are used to obtain up-to-date information on the state of environmental transformation under the influence of anthropogenic factors, to identify sources that form risk factors and to formulate recommendations for their prevention and overcoming (if any). Processing and modeling is performed on the example of simulation models in the environment of geographic information systems, such as Software Surfer. A necessary step in the management of environmental quality monitoring is direct engineering and technical reconnaissance (field research with a visit to the problem sites and areas). The relevant segment is provided with specialized tools: geodetic instruments - total stations, laser scanners, satellite monitoring kits to record dynamic (transient) phenomena and processes, such as ammonia spillage or deformation of engineering structures and structures that are destroyed under the influence of natural conditions. At the operational (emergency) local level of emergency, when there is an urgent need to coordinate the sources of industrial and anthropogenic pollution, it is possible to use gadget software GPS, namely Android applications: GPS Status & ToolBox Professional and GeoDesist. Their use will allow iterative prediction of the geospatial aspects of the spread of, for example, highly toxic substances and, with the help of command means to prevent and inform the population, to carry out operational emergency measures to evacuate the population in the relevant areas.

With the introduction of unmanned aerial vehicles in the environmental quality management system, as part of aerospace systems, the level of operational awareness of relevant state and municipal institutions, relevant specialized rescue teams, which allow online monitoring of the situation and real decision-making. The technological functionality of the transfer of relevant streaming operational geoinformation and its transformation into digital object and area symbols on electronic orthophotos, creates the preconditions for quality management (taking control) of any emergency that will potentially reduce human and financial losses.

At some stages of observational reconnaissance, which do not require high positioning accuracy, navigation systems of a branched operating network of cellular LBS-navigation are used. In some cases, gravimetric, astronomical and geodetic and hydrographic methods are used to study the transformation of geodata update systems for geoinformation modeling of the environment.

It is now necessary to introduce multi-faceted digital imaging, such as digital robotic terrain tacheometry, integrated with satellite location methods. The presence of integrative modules of geointelligent systems with satellite receivers ensures optimal operation of the organization, environmental safety and labor protection. A typical electronic observational monitoring geographic information map of the environment has the following layers: road network, hydrography, vegetation, hazardous enterprises, places of extraction and occurrence of minerals, bridges, tunnels and transport bifurcation. The relevant cartographic product contains the following additional operational and tactical elements of the thematic workload: railway platforms and stations, terminals and civil defense points in order to develop and implement schemes for evacuation of the population and maps of measures to eliminate disasters and their consequences. For example, modern ecological and hydrographic maps of nature use, along with information about the dangerous features of water transport connections, also reflect the peculiarities of economic activity in the water areas or determine the places of release of dangerous toxic substances. Such information is more and more socially significant, especially during the substantiation of the territorial organization of the management system of ecological observational monitoring of the environment, implementation of measures of rational nature use and protection of the natural environment.

One of the modern directions is the use of SMART & MindMap-technology in the methodology of observational monitoring. SMART-technologies in modern technological innovations in conducting observational environmental monitoring are extremely diverse. Cybernetic techniques in the form of SMART & MindMap technology are a specialized direction of the SMART-method in observational reconnaissance of the area. They are called - the method of mental (mental) map of the area. SMART & MindMap technology, namely its structure, is exclusive and unique, which is compared with the technique of neural programming, which reproduces the mechanisms of imaginary (mental or virtual) mapping. From the point of view of neural cybernetics, the corresponding paths of mental (mental) maps are formed by nerve cells in the representation of geospatial information in scientists of the expedition group. The set of corresponding paths forms in the researcher's imagination a mental map of observational geoinformation. This enhances the effectiveness of collective thinking and perception of ecological and geographical information, ie the formation of geoengineering (system-logical) thinking and analytical processing of the current situation in the environment-space. This is especially important in dealing with the consequences of environmental disasters.

4.2. The value of artificial intelligence in plant breeding

Olha Shulha
Doctor of Economics, Associate Professor
Associate Professor of the Department of management and marketing
State University of Intelligent Technologies and
Telecommunications Kyiv, Ukraine
E-mail: shulga_olga_a@ukr.net
ORCID ID 0000-0002-3230-3124

Today, the effects of industrialization include climate change, dangerous levels of air pollution, depletion of fish stocks, toxins in rivers and soils, excessive debris on land and in the ocean, reduced biodiversity and deforestation. As the Fourth Industrial Revolution (Industrial Revolution 4.0) is gaining momentum, the interconnectedness of technology is growing - the digital, physical and biological worlds are merging, and innovation is spreading faster.

That is, in the XXI century, the concept of agricultural development has also become the Industrial Revolution 4.0, the essence of which is that all physical objects will be in some way permanently connected to a single global network to exchange information without the involvement of this person. It is based on the following nine developments of scientific and technological progress:

1. Large databases and their analysis. Thanks to information and communication tools and technologies, the amount of structured and unstructured data in business, coming from a large number of different sources, only grows and there is a problem of quickly obtaining the necessary valuable analytical information to make informed and effective management decisions. The process of finding a large amount of information and its further processing is called «Big Data». In addition, the data mining procedure remains relevant.

2. Autonomous works are works that are able to perform tasks independently without human intervention.

3. Modeling is currently used to a large extent only at the stages of designing production business processes, individual new production equipment or new products.

4. Horizontal and vertical system integration. At present, modern information and communication tools and technologies allow to unite all its divisions, within one logistics supply chain of all its participants, etc. into a single information space within one enterprise.

5. The Industrial Internet of Things will connect all components of production into a single network of real-time information exchange.

6. Cybersecurity involves measures related to the protection of data storage and processing, networks of their transmission.

7. Clouds (cloud technologies), the productivity of which will increase, providing almost instant access and data processing.

8. Additive (additional) production, the basis of which is 3-D printing, with which prototypes of future finished products are already created and simple parts and finished products are produced.

9. Augmented (or virtual) reality will be used by employees of enterprises for training, decision-making, etc.

Thus, the basis of the Industrial Revolution 4.0 is information tools and technologies, which are based primarily on scientific, managerial and information innovations, which, in turn, requires a revision of approaches to agricultural production. These principles should include those that, above all, determine the adaptability of agricultural technologies to natural conditions, safety and quality of products, conservation of biodiversity and agricultural landscapes.

The latest technology of the industrial revolution 4.0. is artificial intelligence. Artificial intelligence is a term used to describe computer systems that are able to feel their environment, think, learn, and act on their feelings and programmed tasks. It is expected that among all the technologies of the Industrial Revolution 4.0, it is artificial intelligence that will have the strongest impact due to its spread in all technological spheres and the growth of its role in everyday life. As the number of intelligent devices, applications, and interconnected systems grows, and with the combination of other new technologies, artificial intelligence becomes the driving force behind the Industrial Revolution 4.0. In addition to gaining productivity, artificial intelligence also opens up unattainable opportunities for humanity to gather information, creating the conditions for new discoveries.

Artificial intelligence is already transforming traditional industries and everyday life. New revolutionary advances based on artificial intelligence are often effective only in combination with other technologies of the Fourth Industrial Revolution. While entrepreneurs, companies, investors and governments are looking for ways to implement and scale these technologies to create strategic benefits, there are also important opportunities to address emerging and pressing challenges for the entire Earth, as well as to create opportunities for today. and the future. The list of types of artificial intelligence currently includes:

1. Automatic intelligent systems that provide automatic execution of repetitive time-consuming tasks that require the use of intelligence. An example is a robot that can learn to sort recyclable household materials.

2. Semi-automatic intelligent systems that test and detect patterns in historical data, such as unstructured social media publications, and help people perform tasks faster and better with selected information. For example, techniques such as in-depth training, natural speech processing, and anomaly detection allow the detection of advanced indicators of hurricanes and other large-scale weather events.

3. Intelligence enhancement systems that use artificial intelligence to help people understand and predict the uncertain future. For example, artificial intelligence-driven control simulators will be useful in exploring scenarios related to climate policy and greenhouse gas emissions.

4. Autonomous intelligent systems that automate the decision-making process, eliminating the need for human intervention. An example is systems that can detect algorithms in the operation of home heating systems that lead to excessive consumption and financial costs, and automatically adapt the mode of operation to save money for the homeowner.

Artificial intelligence has the potential to transform the methods of monitoring and preserving habitats. For example, artificial intelligence can be a fundamental element of technology, which in combination with satellite imagery can automatically detect changes in land use, analyze the condition of vegetation, forests and greenery, as well as monitor floods. For example, PlanetWatchers analytical materials, obtained through careful landscape monitoring, provide a source of information for forest habitat management and address climate change issues such as pests, destruction, droughts and fires.

Machine learning and computer analysis of video information are used to monitor and control invasive plant species. These methods allow to determine the presence of invasive species and plant diseases, to monitor and destroy them. For example, Blue River Technology uses computer analysis of video information and artificial intelligence capabilities to detect and identify changes in biodiversity, including the detection of invasive plants. Protection of flora and fauna from illegal trade is realized by combining the capabilities of artificial intelligence with shooting from a drone.

Currently, artificial intelligence is becoming increasingly important in plant breeding. Today in the United States, KWS is developing and testing a field robot, studying its ability to independently and accurately determine plant characteristics, to obtain higher yields and increase crop resilience.

If you look at the TerraSentia robot from the edge of the field, you can see how a thin bar with a black tube oscillates from side to side among the wheat ears. Equipped with an electric drive and GPS-navigator, the knee-high robot moves across a well-marked experimental field in Champaign County, near Chicago, Illinois. Thanks to its gears, the robot easily moves through lumps and furrows, deftly following its route across the field. In the pipe fixed on a bar two cameras without a stop take detailed pictures of a wheat field depending on movement of the robot. In addition, the robot keeps the exact coordinates of the shooting location. Thanks to this, breeders know which of the stages of development (for example, ear yield) was achieved by sowing in a particular area. To date, such a survey of crops was conducted by people who went out into the field in any weather.

The basis of this system is not a four-wheeled robot, but a program based on artificial intelligence, which is installed on computers KWS and EarthSense. The concept of «artificial intelligence» is used when the machine gives results that in other circumstances are attributed only to human activity. Artificial intelligence analyzes the images taken by the robot and identifies the phases of interest to breeders.

To perform such work, the program must first be taught, as by itself it cannot identify plants. Wheat breeders Jan Murche and Mark Christopher analyze the images taken by the robot. Important parameters shown in the pictures include ear yield, plant height and spinning. Another aspect of interest to breeders is the noticeable symptoms of leaf and ear diseases.

After that, data specialists upload to the program the information received from breeders. For example, if the pictures show spikelets that have appeared in full and spikelets that have appeared in part, the program learns to detect them on the plot within a specified time.

The program generates its knowledge base based on the experience of repeating actions. Thus, its neural network creates a new mathematical model, a certain algorithm. This is what people call «learning» Having received enough information from a person, artificial intelligence immediately uses them to compare new images and make decisions. As for this robot, it evaluates images of plants without requiring human intervention. But if you analyze another crop, such as sugar beets, and not wheat, then again a person will have to teach the machine to see the key differences. With each new task, the neural network must be retrained, and the algorithm must be adapted.

The results of using the first version of the program from 2018 show that the algorithm is already working accurately. Artificial intelligence detects the appearance of spikelets with an accuracy of 96% and determines whether the spikelets, with an accuracy of 92%. Now the system is constantly improving. TerraSentia's task is to inspect the field daily, and, if necessary, twice or even three times a day.

Artificial intelligence and robots can help breeders gather more information on which to base their decisions. However, only breeders can teach the system exactly how to get the information they need. The combination of human and machine intellectual capabilities makes the selection process faster and more accurate. Thus, working with artificial intelligence and autonomous work is an important part of KWS's research strategy.

The more robots used in the field, the more data breeders receive. With the help of robots, breeders can create plants that are more resistant to disease, better adapted to weather changes and provide farmers with stable and high yields.

TerraSentia can be easily moved in different types of fields and is relatively easy to manufacture. The previous model was created on a 3D printer. Navigation systems and digital cameras are widely used and standard today. This means that the number of robots can be increased quickly. If necessary, the program for learning and managing the neural network can be downloaded from the cloud with a single keystroke at any time. However, many researchers around the world are working to expand the capabilities of artificial intelligence, for example, trying to reduce the number of images needed for its training.

4.3. New ways to grow food without land and sun

Olha Shulha
Doctor of Economics, Associate Professor
Associate Professor of the Department of management and marketing
State University of Intelligent Technologies and
Telecommunications Kyiv, Ukraine
E-mail: shulga_olga_a@ukr.net
ORCID ID 0000-0002-3230-3124

Agricultural technologies do not stand still. *Growing plants in high rows without the sun has become one of the popular trends in recent years*. Currently, vertical farms are actively developing in many countries.

Vertical farming involves the intensive use of available territories and resources. The multilevel arrangement of plants allows to increase productivity hundreds of times and to save 70-95% of water, in comparison with traditional cultivation of various cultures.

The first vertical farm is considered to be Singapore's SkyGreens, designed in 2009. Since 2012, vegetables and fruits grown in the garden tower have been available in 200 Singaporean stores. Every day this vertical garden produces 800 kilograms of environmentally friendly products. At this plant, plants are grown in two ways: soil and hydroponic.

The main «motor» of production capacity was rainwater and the force of gravity, which ensures the movement of 38 beds-containers. Nano-beds revolve around a nine-meter tower and thus receive the required amount of light and moisture. Note that on the territory of SkyGreens there are thousands of such towers. The Singaporeans have achieved incredible results: they are forcing the 1,700-

kilogram tower to rotate with just half a liter of water and 40 watts of energy. The same water is later used for watering plants.

Every year, new vertical farms appear on the planet, which amaze with their architecture, area and automation. However, common to all vertical farms are: the desire for energy independence through the use of alternative energy sources; flexibility of a design that allows to add modules and compartments; availability of water collection and treatment system, as well as waste processing.

GlobalMarketInsights analysts have concluded that by 2024, vertical farms will account for $ 13 billion. 70% of this share will belong to AeroFarms and Plenty. AeroFarms is the largest vertical farm in the world. It is located in the United States, in the state of New Jersey. 250 different crops are grown on an area of 6,500 square meters. For example, in just one year the company produces 900 tons of lettuce. On this farm, the plants are in trays, which are placed in special blocks, 10 meters high. Crops receive the necessary light from LED lamps. Due to the constant rotation, vegetables and fruits receive the necessary moisture and nutrition. All vital indicators of plants on this farm are read online by special sensors.

Farms of another American company Plenty were able to increase productivity by 350 times compared to conventional fields, using only 1% of water. This corporation, located in San Francisco, grows a variety of leafy vegetables. Plenty specialists have been able to achieve high productivity through the development of technology: machine learning, the Internet and digital systems for calculating utilities. Soon the company plans to switch completely to solar energy. In addition, their products are environmentally friendly. Due to the isolation of plants are almost not damaged by parasites.

There are the following methods of growing plants without the use of soil: hydroponics, aeroponics and aquaponics. The method of hydroponics involves the use instead of soil of mineralized and saturated with nutrients water, the method of aeroponics - the delivery of nutrients to the roots through the air, in the form of an aerosol. Aquaponics is a system that uses the relationship between plants and fish. Consider in more detail each of these methods.

Hydroponics is a fairly old type of plant growing. Its essence is that the roots of plants receive the necessary nutrients not from the earth but from water. Hence the name of the method from the word «hydro», which means «water». For example, in ancient times hydroponics was used in a very original way. In places where there was catastrophically little soil suitable for growing vegetables, people lowered rafts covered with silt, into which they planted vegetable crops. The roots of the sprouts made their way through the logs and fed on nutrients dissolved in water. It is clear that today hydroponics is largely modernized.

Different countries of the world are actively involved in the development of hydroponics technology. Countries such as Australia and New Zealand, South Africa, Italy and Spain, Israel and the Nordic countries are showing interest in this system. In Europe, many vegetables and berries are grown by hydroponics. The use of state-of-the-art nutrient solutions makes it possible to significantly increase crop yields, as well as reduce the area under their crops.

Hydroponics allows you to grow almost all crops (lettuce, dill, onions, mint, etc.), even fruit and exotic plants. This method is well suited for planting strawberries and wild strawberries. With the help of hydroponics you can grow legumes, tomatoes, cucumbers, onions, physalis, vines and more.

In comparison with classical cultivation of plants the hydroponic technology allows to accelerate sharply growth of the last, to increase their productivity, to provide ecological purity and high quality of agricultural products. The possibility of using soil substitutes is explained by the fact that the soil supplies plants with only 5% of minerals, the other 95% of the plant itself synthesizes from carbon dioxide and water in the light.

However, this method of growing plants has one drawback: it is impossible to grow tuberous plants (potatoes, beets, carrots, radishes). The fact is that the very principle of the method involves finding the roots in water. And if ordinary roots receive nutrients from water and absorb them for plant growth, the tubers can not tolerate such moisture that leads to rot. For other plants, hydroponics is an excellent method that can significantly accelerate plant growth, save usable space, money and labor costs.

Advantages of the hydroponic method of growing plants:

1. When using this method significantly increases the yield of fruit plants. This method helps to provide the plant with all the necessary nutrients. It grows much faster than in the soil.
2. The plant does not accumulate harmful elements contained in the soil, which have a detrimental effect on the human body. Typically, these are toxic organic compounds, excess nitrates, radionuclides, heavy metals and more.
3. Plants do not need daily watering. And water consumption in hydroponics is much easier to control. Depending on the growing system and the volume of the tank, it is necessary to systematically add water (one plant once every three days, the other - once a month). In addition, when growing soil, plants often suffer from drying out and lack of oxygen in case of waterlogging. With the use of the method of hydroponics, this is completely excluded.
4. The procedure for transplanting perennials using hydroponics technology is significantly facilitated. After all, when transplanting them into the soil, the roots are in any case injured to one degree or another. Thanks to hydroponics, it is possible to prevent problems such as pests and various types of fungi and diseases that occur in plants grown in the soil.

The disadvantage of using hydroponics technology is that the initial cost of such a solution will be significantly higher than the purchase of conventional soil. However, the initial cost of time and money will pay off quickly, as the plant will grow several times faster and take care of it will be much easier.

Aquaponics is a combined method of growing fish and plants together in a recycling ecosystem using natural bacterial cycles to convert fish waste into plant nutrients. This is an environmentally friendly method that uses the best attributes of aquaculture and hydroponics without the need to add chemical fertilizers, discard water or filtrate.

Aquaponics is a system where plants and fish are grown together in symbiosis. The products of fish life provide food for the plant, and the plants, in turn, filter the water that returns to the fish. Aquaponics can be called a combination of two other methods of cultivation: hydroponics and aquaculture. Aquaculture must be provided with constant waste disposal, preventing the achievement of toxic levels for fish. Hydroponics requires constant replenishment and manual balancing of chemicals. Aquaponics makes it possible to significantly reduce, and in some cases reduce to zero, wastewater discharge.

Aquaponic systems are usually grouped into several components or subsystems that are responsible for efficient waste disposal, adding a base to neutralize acids or to enrich water with oxygen. Typical components of such a system include:

• breeding tank: tanks for breeding and feeding fish;

• settling tank: a unit for catching feed residues, separated biofilms and for separating small particles;

• biofilter: a place where bacteria can grow and convert ammonia into nitrates needed by plants;

• hydroponic subsystems: part of the system where plants are grown by absorbing excess nutrients from water;

• tray: the lowest point in the system where water enters and from which it rises back into the tanks.

Aeroponics is considered a new technological direction of hydroponics, which allows efficient use of water and nutrients. Through this system, the nutrient solution is fed to the roots of plants in the form of an aerosol. The principle of this system is that the roots of the plants receive food and water from the dry mist created by the fine sprayers. The roots of the plants are placed in a closed container or system, where they have free access to air, sprayers regularly provide food every few minutes. The timer controls the nutrient supply pump in the same way as in other types of hydroponic systems. Aeroponics differs in the frequency of the pump: you need a short cycle timer that starts the pump for a few seconds every few minutes.

Sometimes use aeroponics, which is sprayed constantly, without a timer. The main advantage of aeroponics is the ability to grow flowers and greenery in hydroponic towers, using the vertical space of the greenhouse. Some experts claim that the future will come very soon, when multi-level greenhouse complexes will be located directly in the cities, which will work according to the aeroponics system.

Disadvantages of aeroponics:

1. Too active root growth.

2. Because the roots are exposed to air, when spraying stops, the roots dry quickly.

3. The system is contaminated with anaerobic bacteria from rotting plant roots, which can only be handled by experienced gardeners and agronomists.

However, aeroponics is not easy to use and using it you need to be prepared for the risks of plant diseases during cultivation.

By the way, the FarmedHere farm in Chicago, which occupies the territory of the former warehouse, became the first vertical farm certified by the USDA. The plants on this farm are grown using the method of aeroponics and aquaponics as follows: tilapia fish are launched into a container of water, the products of which contain nitrogen, which is a fertilizer for plants. In turn, plants absorb excess nitrogen from the water and emit oxygen. Both plants and fish benefit. The productivity of this farm is 20 times higher than similar indicators of a similar farm, where traditional methods of cultivation are used.

4.4. New models of yield forecasting and data analysis

Olha Shulha
Doctor of Economics, Associate Professor
Associate Professor of the Department of management and marketing
State University of Intelligent Technologies and
Telecommunications Kyiv, Ukraine
E-mail: shulga_olga_a@ukr.net
ORCID ID 0000-0002-3230-3124

There are several basic approaches to forecasting crop yields. The first is the *traditional method* of harvest forecasting. In particular, it is possible to determine the biological yield of corn grain by the elements of the crop structure, in particular:

1. Pre-harvest density of plants, thousand pieces / hectare.

2. Elements of the structure of the cob – the number of grains in the cob (the number of rows of grains and the number of grains in a row).

3. Weighing 1000 seeds.

To calculate the biological yield, you need to multiply the pre-harvest density of standing by the weight of grain from the cob.

The second *is empirical*, which is based on the use of remote field data – a set of vegetation and biophysical indices derived from satellites, drones or ground sensors. The approach is one of the most widely used, as it does not require «expensive data» and is the most accessible. At certain stages of the growing season, farmers can use the NDVI index to determine yields on their own, and this will be much more effective than the traditional method.

The third approach involves the use of biophysical simulation models – *mathematical models* that predict yields by simulating the growth and development of plants. To implement this approach, it is necessary to have access to an extremely wide range of data on plant variety, soil, climate and other important factors that directly affect the yield.

Farmers of various European scientific communities take into account the capacity of the soil for moisture to a certain depth, the productive reserve of soil moisture, crops, variety specifics, critical temperatures, key phases of the growing season and more. Of course, models with data from these parameters are more accurate because they depend on the parameters of the field, but they require possession of information that is difficult to collect, and which at the same time requires money. However, farmers can use AgroOnline as a tool in combination with traditional forecasting. The clients of the service are provided with the service of satellite monitoring of crops in a separate module «production». There you can track the current picture in the fields, as well as the historical dynamics of changes in indices, analyze the heterogeneity of plant development and set auditors the task of conducting ground surveys of «suspicious areas».

P. Hrytsiuk proposed new methods for forecasting time series of grain yields.

1. *Harmonic model.* One of the main features of the deterministic behavior of the system is cyclicity. Linear conservative systems are characterized by a clearly periodic cycle. Most natural and economic systems belong to the classes of nonlinear dissipative systems and nonlinear self-oscillating systems. Such objects are characterized by oscillations with variable values of period and amplitude. Studies have shown that the time series of winter wheat yields are characterized by short cycles lasting 4 years and medium cycles lasting 16-20 years. The short cycle is most likely caused by cyclical weather and climatic factors, the middle can be explained in the framework of the model «yield – fertility», which is a model of the type «predator – victim». An effective way to model time series with the effect of cyclicity is a polyharmonic yield model, which is based on the hypothesis that the yield function is the sum of several harmonics and a random factor (noise).

2. *Method of analysis of difference series.* An effective mechanism for predicting the time series is the study and modeling of a number of first differences. The advantage of this approach is the correct reproduction of the sequence of increments and declines, which is especially important for modeling the dynamics of

the time series. If the time series is next to independent increments, the probabilities of increments and declines are the same. The effect of persistence rejects this possibility. Therefore, the corresponding probabilities must be estimated for each specific time series.

3. *The method of nearest neighbors*. It is based on the idea of the proximity of phase vectors. The basic idea is that close phase vectors evolve in the same way over a short period of time.

4. *The method of neural networks*. In recent years, one of the most promising approaches to building prediction systems is the use of multilayer neural networks. Between the input and output data of such networks are several hidden layers of neurons, which add more nonlinear connections to the model.

Data analysis is a complex, multi-step procedure, at each step of which a special mapping is built and mathematical methods of data processing are applied. The formation of the analysis process is associated with the need to reconcile these methods on the sets of arguments and values of the respective operators. Such an agreement can be performed only if each step of the process is submitted by the operator, and the agreement is established on the basis of the correspondence of the results of one step and the arguments of another. This will allow you to describe different analysis processes based on general considerations.

Analysis of large amounts of data requires processing methods that go beyond traditional statistical methods. There are the following techniques and methods of analysis that are applied to large data, taking into account the functional relationships and formal model of this information technology: Data Mining methods, Techt Mining technologies, data visualization, other technologies and analysis techniques.

Methods of data mining (Data Mining). The application of Data Mining methods and technologies allows to solve the following tasks: classification, clustering, association, sequence or sequential association, forecasting, determination of deviations, analysis of deviations or emissions, evaluation, analysis of relationships, visualization, summarizing. Data Mining methods are divided into two groups: statistical and cybernetic methods. Consider some of them.

Classification. A set of methods that allow predicting consumer behavior in a particular market segment (purchasing decisions, consumption, etc.). The decision tree method is one of the most popular methods for solving classification and forecasting problems. In its simplest form, the decision tree is a way of presenting rules in a hierarchical, consistent structure.

Cluster analysis. Statistical method of classifying objects by groups as a result of identifying previously unknown common features. An example is market segmentation. Associative rules. A set of techniques for identifying relationships, ie associative rules, between variables in large data sets. To analyze the market basket, the analysis of hidden patterns is used. Regression. A set of statistical methods for identifying patterns between changes in a dependent variable and one or more independent ones.

Time series analysis. A set of methods for analyzing repetitive data sequences over time, borrowed from statistics and digital signal processing. Neural networks. This is a class of models that are based on analogies with the workings of the human brain and are designed to solve various problems of data analysis after passing the stage of learning on data. With the help of neural networks, you can, for example, predict sales, recognize signals, develop self-learning systems.

Data visualization. Methods of graphical presentation of the results of big data analysis in the form of diagrams or animations to simplify interpretation, facilitate understanding of the results. Text Mining Technologies. The basis of Text Mining technology is statistical and linguistic analysis, methods of artificial intelligence. This technology is used for analysis, navigation and search in unstructured texts. The use of Text Mining class information systems allows users to acquire new knowledge. An example of the effective application of Text Mining technologies is content analysis.

Spatial analysis. Spatial analysis – the use of topological, geometric and geographical information in data. A set of data analysis techniques partially borrowed from statistics. The source of big data in this case is geographic information systems.

Statistical methods are often used to make judgments about the relationship between events. Modeling. Modeling the behavior of complex systems is often used to predict, predict, and process different scenarios during planning.

Crowdsourcing. Methods of collecting data from a large number of sources. Crowdsourcing – categorization and enrichment of data by a wide, indefinite circle of people, in order to use their creative abilities, knowledge and experience with the use of information and communication technologies.

Data merging and integration. A set of techniques that allow you to integrate disparate data from different sources of information for in-depth analysis.

REFERENCES

Shevchenko R. YU. (2020) Instrumentariy monitorynhu dovkillya mista Kyeva [Instrumentarium of environmental monitoring of the city of Kyiv]: *monograph*. Kyiv, 324 p.

Kherveyer S., Uohrey D. (2018) Chetverta promyslova revolyutsiya zarady Zemli Vykorystannya mozhlyvostey shtuchnoho intelektu na koryst Zemli [The fourth industrial revolution for the sake of the Earth Using the capabilities of artificial intelligence in favor of the Earth]. Retrieved from: https://www.pwc.com/ua/uk/survey/2018/ai-for-the-earth-jan-2018.pdf (Last accessed: 10.09.2021)

Pole z maybutnim: zastosuvannya shtuchnoho intelektu dlya pokrashchennya yakosti nasinnya [Field with the future: the use of artificial intelligence to improve seed quality]. Retrieved from: https://www.kws.com/ua/uk/media-ta-innovatsiyi/presa/world-of-farming/pole-z-majbutnim-zastosuvannya-shtuchnogo-intelektu-dlya-pokrashchennya-yakosti-nasinnya/ (Last accessed: 10.09.2021)

Skitsko V. I. (2016) Industriya 4.0 yak promyslove vyrobnytstvo maybutnoho [Industry 4.0 as the industrial production of the future]. *Investments: practice and experience*, 5, pp. 33-40.

Vertykalni fermy: vysoki tekhnolohiyi proty holodu [Vertical farms: high technology against hunger]. Retrieved from: https://enovosty.com/uk/tehnologii-ukr/full/609-vertikalni-fermi-nagoduyemo-ves-golodnij-svit (Last accessed: 10.09.2021)

Vlasova O. Unikalnyy sposib vyroshchuvannya roslyn [A unique way of growing plants]. Retrieved from: http://agro-business.com.ua/agro/ahronomiia-sohodni/item/424-unikalnyi-sposib-vyroshchuvannia-roslyn.html (Last accessed: 10.09.2021)

Prohnozuvannya vrozhaynosti kukurudzy za dopomohoyu indeksu vehetatsiyi ta suputnykovykh znimkiv [Prediction of maize yield using the vegetation index and satellite images]. Retrieved from: https://superagronom.com/blog/750-prognozuvannya-vrojaynosti-kukurudzi-za-dopomogoyu-indeksu-vegetatsiyi-ta-suputnikovih-znimkiv (Last accessed: 10.09.2021)

Hrytsyuk P. M. (2010) Prohnozuvannya vrozhaynosti zernovykh kultur: osoblyvosti i metodyka [Forecasting grain yields: features and methods]. Retrieved from: http://ir.kneu.edu.ua/bitstream/handle/2010/5938/294%20-%20300.pdf?sequence=1&isAllowed=y (Last accessed: 10.09.2021)

Veres O. M., Olyvko R. M. (2017). Klasyfikatsiya metodiv analizu velykykh danykh [Classification of big data analysis methods]. Retrieved from: http://science.lpnu.ua/sites/default/files/journal-paper/2018/jun/13005/ilovepdfcom-84-92.pdf (Last accessed: 10.09.2021)

4.5. Social institutions as a factor of rural cluster development

Serhii Petrukha
Candidate of Economic Sciences, Docent,
Doctoral Student of the Department of Management in Construction of the
Kyiv National University of Construction and Architecture
E-mail: petrukhasergii@gmail.com
ORCID ID 0000-0002-8859-0724

Nina Petrukha
Candidate of Economic Sciences,
Docent of the Department of Management in Construction of the
Kiev National University of Construction and Architecture
E-mail: nninna1983@gmail.com
ORCID ID 0000-0002-3805-2215

Nataliia Alekseienko
postgraduate student,
SESE “The Academy of Financial Management”
E-mail: nalekseienko7777@gmail.com
ORCID ID 0000-0002-6497-6526

At the present stage, essential modernization of the economy and society takes place in Ukraine. It is associated, first, with the transition of the Ukraine’s economy to economic growth on a sustainable development basis that found its expression in implementing the Sustainable Development Goals of Ukraine until 2030 [1]; second, with the reformation of the whole system of public power by decentralization [2] that provides the transfer of significant functions onto lower administration levels and the essential growth in expertise and efficiency of self-government throughout the vertical of exercising the powers of authority. Solution of economic and social problems as well as tasks of modernization assumes mobilization of all resources of the society, first of all, social resources.

The current Law of Ukraine "On the Priority of Social Development of the Village and Agro-Industrial Complex in the National Economy" [3] (hereinafter the Law) establishes the measures for social development of the village providing a list of priority organizational-economic and legal measures to be implemented in rural territories. A minimal amount of state capital investments aimed at strengthening a material-technical base of the social sphere of the village and agrarian sector must be at least 1 % of GDP [4] (at least 50% of state capital investments provided by this item are applied for the construction of non-production purpose facilities in the rural area). However, the Law is disregarded, especially, in terms of providing an advantage to the village as compared to the city (per capita), in erecting housing, institutions of education, culture and sports, healthcare, consumer services, trade, communal facilities, power and water supply etc., and in providing quality medical, cultural, sports, communal-consumer, transport and trade servicing of the village.

The state of the social sphere of the village and, thereafter, the other aspects of life activities of rural territories, as a whole, can be considered by us through the following indicative base:

1. Demographic situation in the rural area (including rural population number decrease/increase).
2. Unemployment level.
3. Labor payment level through an average monthly pay and revenues from the business on household plots (self-sufficiency being a primary source of monetary funds of peasants).
4. Rural population migration indicators through an outflow to cities and abroad.
5. Medical support level through the presence/absence of medical institutions and medical services sufficiency.
6. Sufficiency in a rural education institution network (including the presence of aesthetic education schools).
7. Living conditions of the rural population (including water supply, sewage, central and/or individual heating, availability of bath and shower rooms, floor electric ranges).
8. Level of sufficiency in road transport infrastructure (including connection by public transport between villages and nearest cities).
9. Sufficiency in culture purpose facilities (including staff sufficiency for culture institutions).

We will consider, in detail, the fifth indicator "Medical Support Level Through the Presence/Absence of Medical Institutions and Sufficiency in Medical Services" by the example of the Communal Non-Commercial Enterprise "Center of Medical and Sanitary Care of the Vyshhorod Town Council (CNE “CPMSC” of the VTC), having made, for a start, the description of its activity through the components such as the mission, work principles, values and strategic vision of operation in the market of the provision of medical services in the Vyshhorod Raion.

The CNE “CPMSC” of the VTC operates to care for keeping the health of raion residents and, if needed, provide affordable and quality medical aid by forming friendly relations based on mutual trust and respect, comfortable conditions and expertise of our workers. Good health and wellbeing of raion residents is the main goal of the operation of the healthcare institution. Keeping the health of the population through preventing illnesses and promoting a healthy lifestyle on the basis of partnership, respect and trust between the medical community and population, professionalism of the workers of the institution and its whole branching network in the raion.

The main principles of the activity of the healthcare institution are:

1. Professionalism – in its activity, the institution and its whole branching network in the raion meets the state medical service provision standards, uses performance (evidence-based medicine principles) treatment and health recovery techniques based on innovative domestic and world’s practices. The conditions are created for professional improvement and skill upgrading of employees of the institution and its whole branching network in the raion.

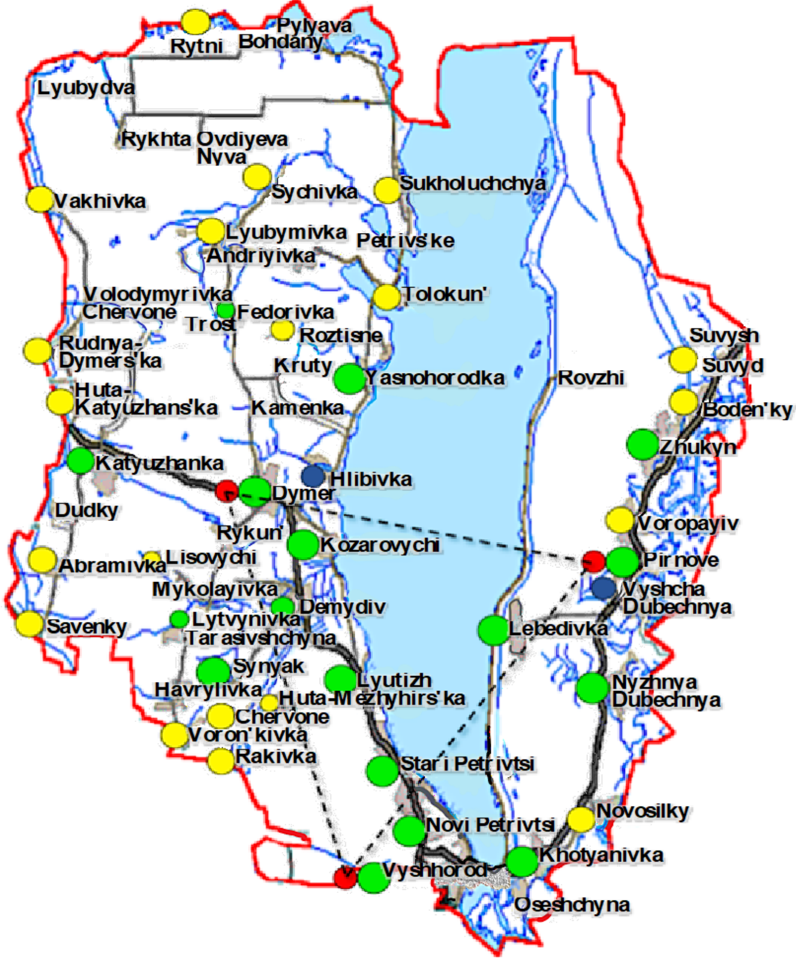
2. Complex approach – the CNE “CPMSC” of the VTC provides a wide range of medical services, uses screening systems for early pathology detection, efficient drug therapy, psychological correction, social adaptation is prescribed, constant preventive work is carried out both at general education institutions and pre-school education institutions and at enterprises operating in the raion. The application of consulting by specialist physicians of secondary and tertiary levels using telemedicine capabilities is being actively implemented.

3. Comfortable conditions – a convenient location of the Center and constant visiting consultation meetings with the patients in the raion’s villages.

4. Partnership and psychological comfort – a patient for the institution is, first of all, a person who is respected and honest partnership relations are built with them. Each patient is supported (assistance in overcoming fear in detecting health problems). The informal slogan of the CNE “CPMSCE” of the VTC is “We don’t treat an illness, we keep and return a human’s health”.

Values of the institution: teamness is a contribution of each employee to achieving the set tasks, keeping medical ethics and deontology, improving the quality of medical services; trust is a mutual understanding between a patient and a family physician in determining a diagnosis, in prescribing drugs by a physician, a decline in self-treatment cases. Assistance to patients in their wish to be informed participants in making a decision concerning their health and welfare; professionalism is continuous self-education of each specialist of the institution (primary care physicians and nurses), orienting knowledge, experience and capacity on solving patients’ health problems on a permanent basis; discipline is exactingness towards themselves and their patients.

Institution's vision: being a leader in the Kyiv Oblast, in general, and in the Vyshhorod Raion, in particular, in innovations, quality of medical services and comfort for the clients. The raion's population unreservedly recognizes our institution as the most desired place for servicing and a medical community – as an innovative development benchmark for the provision of medical services. Leadership positions of the CNE "CPMSC" of the VTC are reflected in the best indicators of the health of the community of the Vyshhorod Raion as compared with other communities of the oblast. We serve our clients on a high quality basis regardless of their place of residence thanks to the active use of remote technologies. We are trusted by the clients thanks to a motivated team, friendly attitude, quality provision of services and comfortable conditions. 85 % of the raion's population choose exactly the CNE "CPMSC" of the VTC to care for their health and 95 %, according to the 2020 survey data, are satisfied with the services provided. The CNE "CPMSC" of the VTC carries out the constant active work on reviving and rooting the family medicine values in the Kyiv Oblast for their patients.



Conventional symbol's: – OCGPFM; – IC; – HC – Twenty-four-hour primary medical care rooms

Figure 39. Geolocation Placement of the Network of CNE "CPMSC" of the VTC

Source: Visualized by authors according to [5–6].

In Fig.39, a locational deployment of outpatient clinics, feldsher's stations, health stations and twenty-four-hour primary medical care rooms subordinated to the CNE "CPMSC" of the VTC is visualized.

1. The total number of subordinated outpatient clinics of general practice of family medicine (OCGPFMs) – 18 units; 2. Feldsher's stations (FSs) – 20 units; 3. Health stations (HSs) – 2 units; 4. Twenty-four-hour primary medical care rooms – 3 units.

It is seen from Fig. 1, that the CNE "CPMSC" of the VTC has a quite branching own network of various kind of institutions to provide medical assistance to the population of the Vyshhorod Raion. But it is necessary to note its inequality and, thus, state the risks of obtaining quality medical service incompletely and untimely by patients. Since, for example, twenty-four-hour primary medical care rooms are concentrated in the "south-central" triangle of the Vyshhorod Raion only. That is why, a problem of patients' logistics before obtaining quality medical services and emergency medical care at any time of the day is raised.

Further, we will look into the organizational-functional characteristic of the CNE "CPMSC" of the VTC. We note that the management of the CNE "CPMSC" of the VTC pays constant and considerable attention to the liberalization of the treatment process, matters of ethics, aesthetics, comfortability of patients' stay at all subordinated institutions because the patients not only want to obtain quality medical services but also expect, having visited the institution, to obtain, first of all, urgency and priority of the solution of exactly their problem (in Fig. 40, the ranking is made, of patients' main expectations according to the results of their secret survey conducted in 2020), creation of the best labor conditions for the medical personnel.

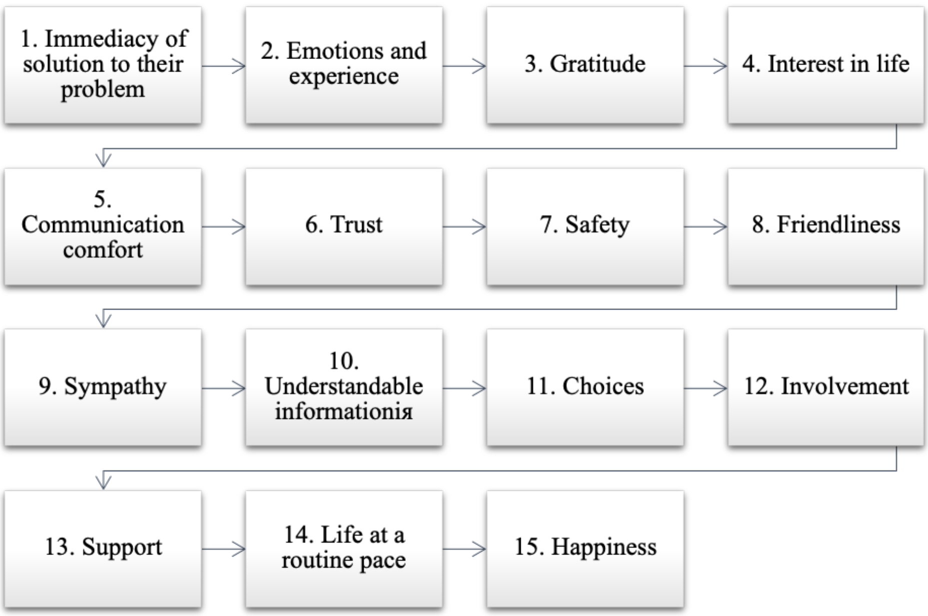


Figure 40. Patients' Main Expectations at CNE "CPMSC" of the VTC Institutions

Source: Drawn up by authors.

Primary medical-sanitary care is provided to the population of the raion by 44 physicians and 134 medium-level medical workers, the supporting personnel makes up 67 workers. Premises of structural subdivisions of the Center are capitally repaired at 94%, provided with the new medical equipment and office furniture. Physicians' workplaces are equipped with the means of electronic communication (notebooks and multifunction devices) and the reception area in 6 outpatient clinics serving over 5 thousand people are equipped with computers that enables to manage electronic services for patients' convenience. All structural subdivisions are connected to the Internet system. Outpatient clinics are fully provided with motor vehicles.

Laboratory examinations, consultations of specialist physicians etc. are carried out on a contractual basis with the secondary link, provide the patients with the quality laboratory and instrument examination, consultations of specialist physicians, inpatient treatment in specialized wards, the provision of emergence care on non-working days and holidays. Medical services are provided to the population in accordance with Order of the MOH of Ukraine No 504 of 19.03.2018 "On Approval of the Procedure of Provision of Primary Medical Care". As an example, in Fig. 41, a patient's clinic route is visualized (as an example, a path is given for a patient ill with laryngitis).

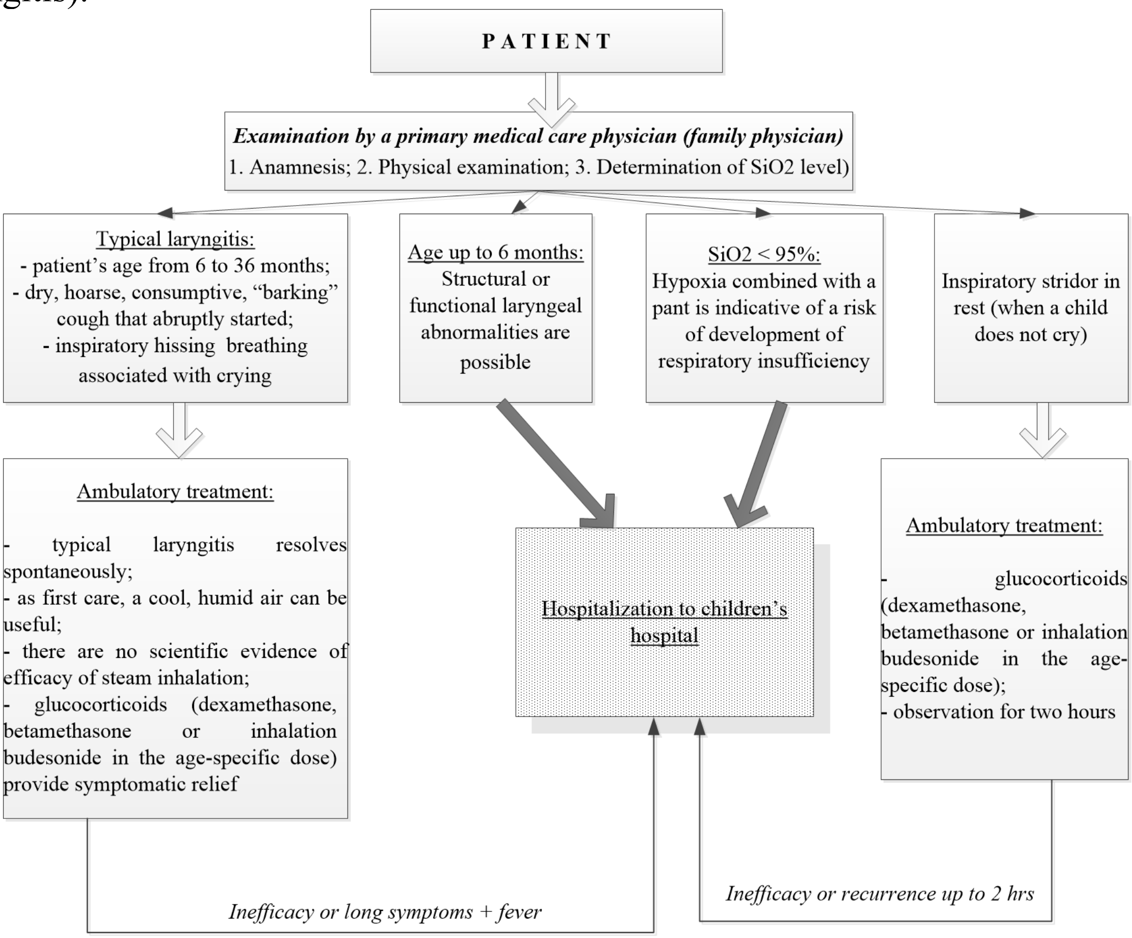


Figure 41. Clinical Route of the Laryngitis Patient of CNE "CPMSC" of the VTC

Source: Visualized by authors.

Which was developed by specialist physicians of the CNE "CPMSC" of the VTC in pursuance of Oder of the Ministry of Health of Ukraine of 28.09.2012, No

751 “On Creation and Introduction of Medical-Technological Documents for Medical Care Standardization in the System of the Ministry of Health of Ukraine”, in the wording of Orders of the MOH of Ukraine of 29.12.2016, No 1422 “On Introduction of Amendments to Order of the Ministry of Health of Ukraine of 28 September 2012, No 751” and of 26.09.2018, No 1752 “On Introduction of Amendments to Annex 4 to the Methods for Development and Introduction of Medical Standards of Medical Care on the Evidential Medicine Basis”, Order of the MOH of Ukraine of 19.03.2018, No 504 “On Approval of the Procedure for the Provision of Primary Medical Care”, to improve the quality of the provision of primary medical care to the patients of the Vyshhorod Raion.

The organizational structure of the management apparatus of the CNE “CPMSC” of the VTC presents a line and staff management system and is presented in Fig. 42. A head of the institution is the chief physician appointed to a position by the Health Department of the Vyshhorod Town Council. The procedure for the operation of the chief physician and making decisions by them is established by the Charter and internal documents of the association. Direct subordinates of the chief physician are: four deputies for public health service, for temporary disability examination, for childhood and maternity protection and for organizational-medical work as well as chief accountant, chief nurse, pharmacist, senior staff inspector and jurist.

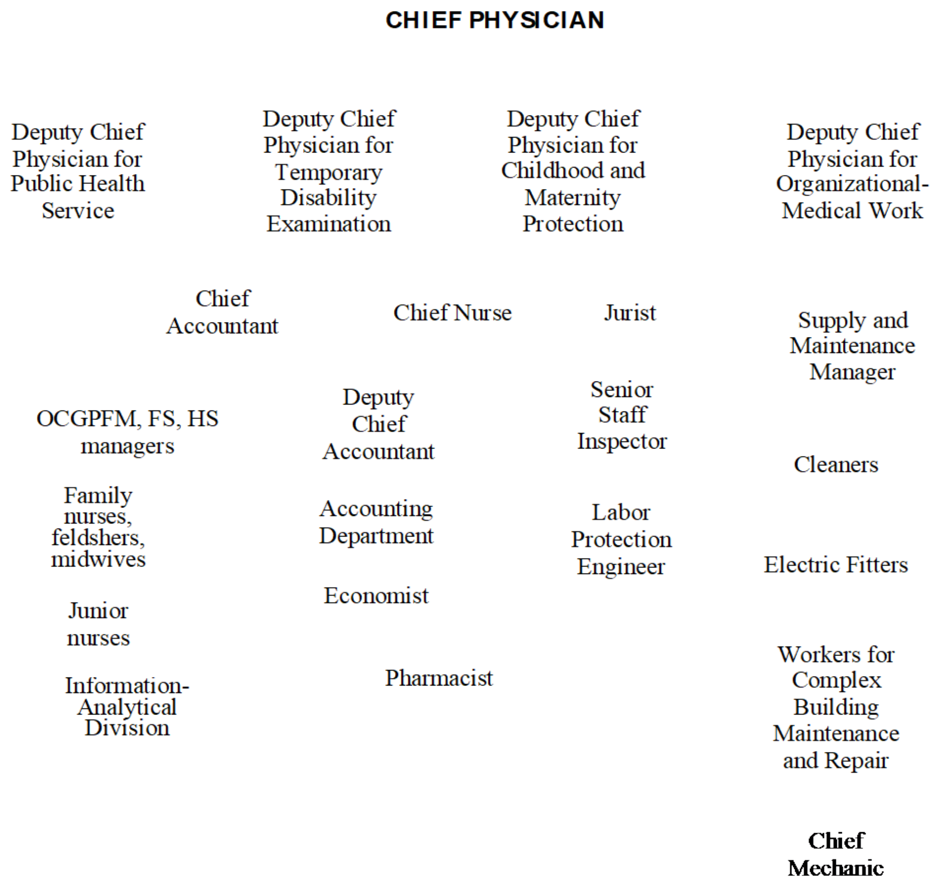


Figure 42. Organizational Management Structure of the CNE “CPMSC” of the VTC

Source: Visualized by authors according to [5].

But is necessary to note that, as of today, the healthcare system of the Vyshhorod Raion, as in Ukraine in general, is characterized by:

- Low human life expectancy;
- Negative natural population growth;
- Low resident health level;
- Growth and incidence of infectious morbidity;
- Insufficient family medicine institution development;
- Secondary medical care development priority;
- Lack of interaction between the primary and secondary medical care links as well as between urgent and emergency medical care.

To solve this range of problems and, thus, elaborate the respective strategy for development of the CNE “CPMSC” of the VTC, it is required to understand the external environment of its existence and how exogenous factors impact (adjust) its activity. Analysis of the exogenous (external) environment of the activity of the CNE “CPMSC” of the VTC, which does not directly depend on the organization but has a direct impact on its work, includes the economic, political, social and technological components for its characteristics. To systemize and visualize the results of characteristics of the external environment of the activity of the CNE “CPMSC” of the VTC, we used widely known PEST Analysis technology [7–8] presented in Fig. 43, and, thereafter, its text assessment is given and a managerial aspect is considered. We can cluster the organizational structure of the healthcare system of Ukraine onto three basic levels [9–12]:

1. A national level of the healthcare system is represented by the Ministry of Health of Ukraine (management entity) and state-owned healthcare institutions subordinated directly to the Ministry of Health of Ukraine as well as scientific research institutes and higher education institutions subordinated to the Academy of Medical Sciences of Ukraine and the Ministry of Health of Ukraine (management object).
2. A regional level of the healthcare system is represented by the departments of healthcare under the oblast state administrations (management entity) and state healthcare institutions transferred into management to them by the respective decisions of the higher bodies of state power as well as by healthcare institutions being in common ownership of territorial communities. For example, oblast hospitals, diagnostics centers etc. (management objects).
3. A sub-regional (local) level of the healthcare system is represented by raion state administrations, raion, city, city’s raion, settlement, village bodies of local self-government (management entity) and healthcare institutions subordinated to these bodies on the rights of communal ownership (management object). It should also include various types of medical enterprises, which are not directly subordinated to the branch and regional bodies of power and are in private or collective forms of ownership: medical centers, hospitals, sanatoriums, clinics etc. However, their activity is licensed by the Ministry of Health of Ukraine and carried out in accordance with all laws and regulatory acts in effect in the country.

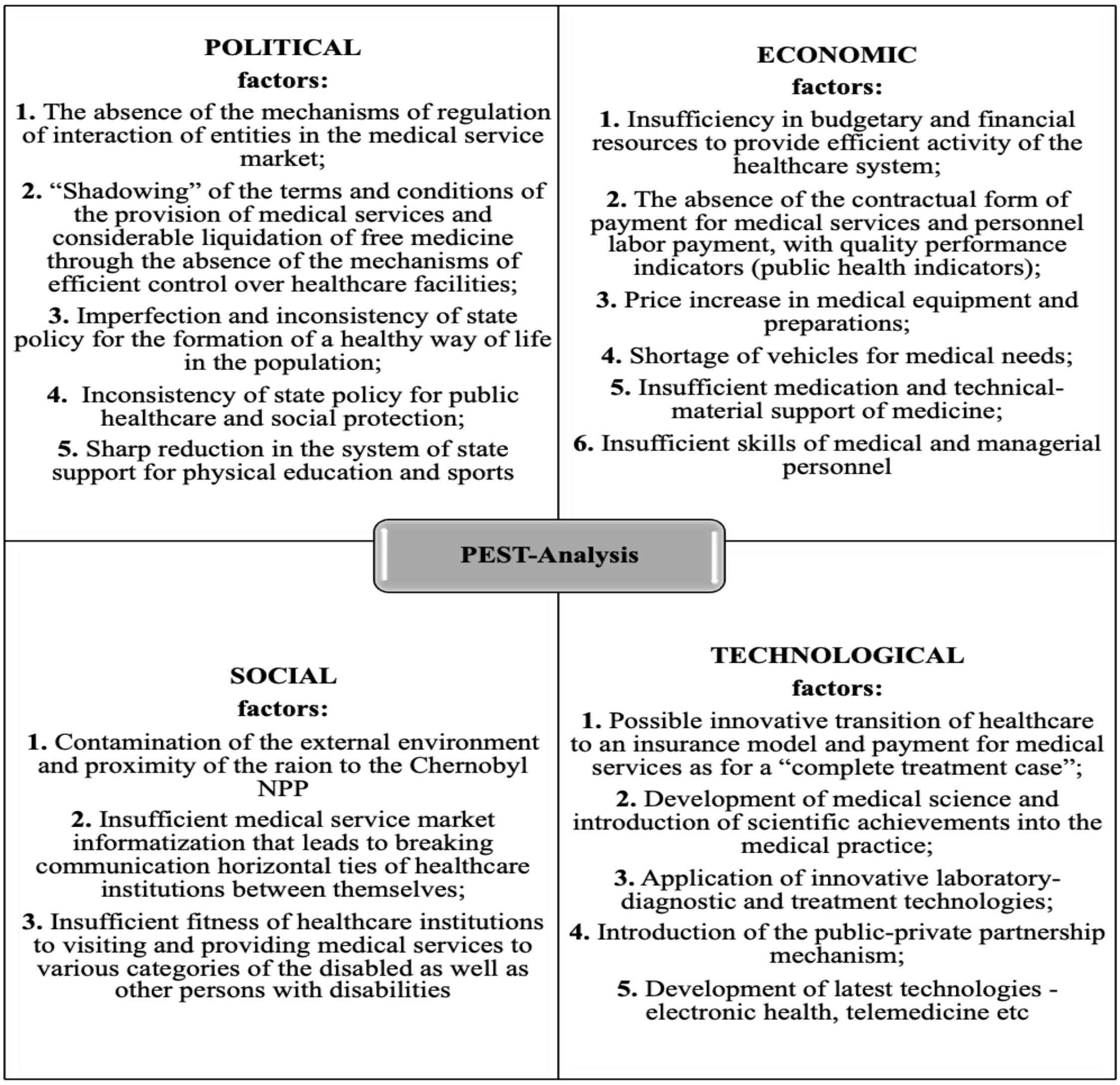


Figure 43. PEST Analysis of the Healthcare System as an Environment for Existence (Activity) of the CNE “CPMSC” of the VTC

Source: Drawn up by authors.

Orders of the Ministry of Health of Ukraine in health care matters issued within its competence are binding upon central and local bodies of executive power, bodies of local self-government as well as enterprises, institutions and organizations [11]. State functions in healthcare are carried out also by other authorities having healthcare institutions in their subordination. These authorities include, for example, the Ministry of Defense of Ukraine, the Ministry of Internal Affairs of Ukraine, the Security Service of Ukraine, the Ministry of Infrastructure of Ukraine. These authorities determine a structure of management of departmental healthcare institutions by themselves.

Healthcare institutions are established also by enterprises, institutions and organizations with various forms of ownership as well as by private persons, upon the availability of the required material-technical base and skilled specialists. A procedure and the conditions for the establishment of healthcare institutions, state registration and accreditation of these institutions as well as a licensing procedure for medical and pharmaceutical practice is set by the acts of legislation of Ukraine. A healthcare institution carries out its activity based on the charter approved by an owner or their authorized body. Regardless of the legal status of the healthcare institution, it may be managed only by a person meeting uniform qualification requirements set by the state. Independence must be provided for a manager of the healthcare institution in solving all healthcare-related matters. The Cabinet of Ministers of Ukraine and its authorized bodies as well as the bodies of local self-government, within their powers, have the right to resolve a matter of termination of the activity of any healthcare institution, if it violates the healthcare legislation, fails to meet the state requirements for the medical care quality and other activity in healthcare or commission of actions contrary to its charter [9; 12].

Ukraine has preserved the system of medical care that existed in Soviet times. It is still not optimized according to the population and its demand for medical services. Direct public healthcare is provided by sanitary-and-preventive, treatment-and-preventive, health-and-fitness, sanatorium –resort, scientific-medical and other healthcare institutions. Over the years of independence, quantitative indicators characterizing the provision of the population with hospital beds and medical enterprises and institutions have worsened more than twofold (Tbl.19).

Table 19

Qualitative-Quantitative Characteristics of the Healthcare System of Ukraine

Researched years	Number of medical institutions		Number of hospital beds			
			total		per 10,000 persons	
	thous.	growth rates, %	thous.	growth rates, %	thous.	growth rates, %
1993	3,9	100	700	100	135,2	99,8
1994	3,9	100	689	98,4	132,6	98,1
1995	3,9	100	679	98,5	130,9	98,7
1996	3,9	100	665	97,9	129,3	98,8
1997	3,9	100	639	96,1	125,1	96,8
1998	3,7	94,9	580	90,8	114,6	91,6
1999	3,4	91,9	503	86,7	100,2	87,4
2000	3,3	97,1	483	96,0	97	96,8
2001	3,3	100	477	98,8	96,5	99,5
2002	3,3	100	466	97,7	95	98,4
2003	3,2	97	466	100	96,6	101,7
2004	3,1	96,9	465	99,8	97,3	100,7
2005	3,0	96,8	458	98,5	96,6	99,3
2006	2,9	96,7	451	98,5	95,7	99,1
2007	2,9	100	445	98,7	95,2	99,5
2008	2,9	100	444	99,8	95,6	100,4
2009	2,8	96,6	440	99,1	95,2	99,6
2010	2,9	103,6	437	99,3	95,1	99,9
2011	2,8	96,6	431	98,6	94,2	99,1
2012	2,8	100	429	99,5	94	99,8
2013	2,5	89,3	412	96,0	90,6	96,4
2014	2,4	96	404	98,1	89,1	98,3
2015	2,2	91,7	398	98,5	88	98,8
2016	1,8	81,8	336	84,4	78,5	89,2
2017	1,76	98,6	332	98,8	78,1	99,5
2018	1,74	98,2	315	94,9	74,3	95,1
2019	1,71	98,3	309	98,1	73,1	98,4

Source: Drawn up and calculated by authors according to [9; 11; 13–14].

As seen, except 2003, 2005 and 2009, a constant reduction has taken place, in providing the population with hospital beds. The highest reduction rates were observed in 1999 (by 12.6 %) and 2017 (by 10.8 %). Over the analyzed period, the number of medical institutions decreased 2.28 times and the total number of hospital beds – 2.27 times. Such reduction could be reasonable in the event of comparable reduction in morbidity and public health improvement. However, statistics says that such reduction was not considerable (by 17%) and, in terms of the number of life-threatening diseases, to the contrary, a gain was observed: by neoplasms +18 %; by diseases of the circulatory system +59 %; by congenital abnormalities +17 % [14]. In additions, the staffing of the healthcare system has also considerably worsened (Tbl. 20).

Table 20

Staffing of the Healthcare System of Ukraine

Researched years	Number of physicians of all specialties				Number of medium medical personnel			
	total		per 10,000 persons		total		per 10,000 persons	
	thous. pers.	growth rates, %	thous. pers.	growth rates, %	thous. pers.	growth rates, %	thous. pers.	growth rates, %
1997	230	–	45,1	–	595	–	116,5	–
2002	226	98,3	46,2	102,4	541	90,9	110,3	94,7
2007	224	99,1	47,9	103,7	496	91,7	106,2	96,3
2012	225	100,4	49,3	102,9	467	94,2	102,4	96,4
2013	224	99,6	49,3	100	459	98,3	101	98,6
2014	217	96,9	47,9	97,2	441	96,1	97,2	96,2
2015	217	100	48	100,2	441	100	97,4	100,2
2016	186	85,7	43,5	90,6	379	85,9	88,6	91
2017	186,23	100,1	43,7	100,5	372	98,2	87,3	98,5
2018	186,78	100,3	44	100,7	367	98,7	86,5	99,1
2019	186,18	99,7	44,1	100,2	360	98,1	85,4	98,7

Source: Drawn up and calculated by the author according to [11; 13–14].

As seen, over 22 years (1997–2019), a reduction in the number of physicians of all specialties took place: in absolute terms by 19.1%, per 10,000 persons – by 2.2 %. The number of the medium medical personnel reduced even faster: in absolute terms by 39.5 %, per 10,000 persons – by 26.7 %. All this tells about weakening the healthcare system and decreasing in its protective function that probably promoted growth in the population's mortality and reduction in its total number. A weak link in labor resource management, in terms of the managerial staff of healthcare institutions, remains staff services, which were not able to establish an effectively operating system of early selection, personal and professional development, multi-faceted managerial staff pool training, giving them the priority in nominating to a managerial position.

A lack of attention to the managerial staff problem had the acutest impact on the economic independence of managers, work in the conditions of using market mechanisms. The present situation characterized by decreasing in the population's satisfaction with the organization and quality of medical care, low satisfaction with the work of medical workers, sharp deficiency in medical personnel is caused to a large extent, by social consequences of the staff policy conducted in the branch.

In the period of intensive changes taking place in the healthcare system in recent decades, a need of the branch to increase the management quality at all levels becomes increasingly obvious that is determined, to a large extent, by the managerial staff, its professionalism, skill to respond to the challenges of time, compliance of its professional-business and personal qualities with the management requirements and vision. At the present stage, the tasks are set before the state to improve the socioeconomic policy in healthcare. Considerable differentiation of regions of the state by socioeconomic and demographic parameters determines the need to consider the features of various types of healthcare branch resources including staff resources in developing a strategy for sustainable development of the branch.

According to the set tasks, the CNE “CPMSC” of the VTC ensures [5]: provision of the population with primary medical care; maintenance of activities for mass and individual prevention of infectious diseases; early detection and prevention of noninfectious diseases, identification of higher risk groups; early detection and prevention of infectious diseases incl. socially dangerous diseases; performance of sanitary-educational work, population training on the healthy way of life, basics of the provision of self-care and mutual care; carrying out of screening of diseases, early detection of which leads to reducing in population disablement and mortality; carrying out of the examination on temporary loss of labor capacity; preparation of the medical documentation for sending the persons with signs of permanent loss of labor capacity for the medical-social examination and for the medical-social rehabilitation; writing out of prescriptions for the preferential provision of specific population groups and by certain disease categories with drugs, according to the current legislation; transitions and consistency of medical examination, treatment and rehabilitation of patients in interaction with other healthcare institutions, according to the medical route of the patient, sending patients for obtaining other types of medical care.

Creation of the OSGPFM-based conditions to carry out visiting appointments by specialist physicians of healthcare institutions of the secondary level; implementation of the human right for a free choice of a physician rendering primary medical care incl. a general practice physician – a family physician carrying out the business activity of medical practice as an individual entrepreneur being in civil law relations with the CNE “CPMSC” of the VTC, a district general physician, a district pediatric physician of the CPMSC etc. However, for the quality task performance, the CNE “CPMSC” of the VTC requires adequate financing from the local budget.

The CNE “CPMSC” of the VTC is able to ensure improvement of health of all segments of the population that will lead to decreasing in the level of morbidity, disability, mortality, continuing active longevity and life expectancy as well as endeavors to promote: development of medical-sanitary care of the population, provision of its high quality and efficacy, priority of development of primary medical-sanitary care on a family medicine basis; improvement of the material-technical base of healthcare according to European standards, implementation of legal, economic, managerial mechanisms, ensuring the constitutional rights of the citizens to healthcare; involvement of mass media, education institutions and social organizations in broader informing the population on prevention, early detection and effective treatment of diseases; introduction of the efficient multi-channel financing system, growth in budgetary appropriations for healthcare; improvement of medical care for vulnerable groups of the population of the Vyshhorod Raion; provision of the population with efficient, safe and quality drugs and medical purpose products under the "Affordable Drugs" state program; enhancement of the efficiency of using financial and material resources of healthcare; creation of the modern information support system in healthcare; improvement of the innovative policy in healthcare; introduction of the system of the personalized electronic register of citizens and modern information and tele-medical technologies in the primary medical-sanitary care activities.

Financing of the CNE "CPMSC" of the VTC is provided within the expenditures approved in the local budget, by decisions of the town council on allocation and application of funds for them, even subject to the current financing of the implementation of measures from the State Budget (state medical guarantee programs) as well as from other financing sources not prohibited by the current legislation. The amount of the specified expenditures is established by decisions of the Vyshhorod Town Council on the budget or on the introduction of amendments to local budget targets for the respective year. We will conduct the monitoring and analysis of financial support of the activity of the CNE "CPMSC" of the VTC in Tbl.21.

Table 21

Analysis of Financial Support of Activity of the CNE "CPMSC" of the VTC

Indicators	2018		2019		2020	
	Local budget	Other sources	Local budget	Other sources	Local budget	Other sources
1	2	3	4	5	6	7
Procurement of medications, dressing materials, medical-purpose products						
Expenditures						
Amount of financing (K hrn)	99.6	-	112.6	-	127.2	-
Product						
Fitting of OCGPFM, FSs and HSs with equipment, medical-purpose products, reagents and disinfecting agents, provision with emergency care drugs, vaccines	43	-	43	-	43	-
Efficiency						
Average unit price	193.0	-	218.22	-	246.5	-
Quality						
Percentage of provision of primary healthcare to population, %	100.0	-	100.0	-	100.0	-
Pay financing and accruals						
Expenditures						
Amount of financing (K hrn)	3,381.6	-	3,821.2	-	4,318.0	-
Product						
Involvement of physicians in working at structural subdivisions of the CNE "CPMSC" of the VTC by filing applications with the Department of Health and, jointly with the village chairpersons, stimulating payments to medical workers of the rural area, setting of differentiated incentive additional payments to physicians and junior medical specialists for	345	-	345	-	345	-

work complexity and pressure in the amount of 50 % of the position salary						
Efficiency						
Average pay (hrn)	4,762.0	-	5,381.0	-	6,081.0	-
Quality						
Percentage of worker labor payment provision, %	100.0	-	100.0	-	100.0	-
Payment for utility services						
Expenditures						
Amount of financing (K hrn)	336.6	-	380.4	-	429.8	-
Product						
Provision of uninterrupted heat, water, light, gas supply	100	-	100	-	100	-
Efficiency						
Average service cost	652.3	-	737.2	-	832.9	-
Якість						
Percentage of provision of payment for utility services, %	100.0	-	100.0	-	100.0	-
Current maintenance of structural subdivisions						
Expenditures						
Amount of financing (K hrn)	658.2	-	743.8	-	840.5	-
Product						
Payment for telecommunication services, garbage removal, acquisition of office supplies, fuel and lubrication materials, provision with computer equipment and network establishment, provision of access to the Internet, introduction of electronic registers and tele-medical consulting	43	-	43	-	43	-
Efficiency						
Average current subdivision maintenance cost	1,275.6	-	1,441.4	-	1,628.8	-
Quality						
Percentage of provision of current maintenance of structural subdivisions, %	100.0	-	100.0	-	100.0	-
Road vehicle procurement						
Expenditures						
Amount of financing (K hrn)	3,800.0	-	3,300.0	-	-	-
Product						
Creation of conditions for efficient operation of the OCGPFMs, FSs and HSs, growth in percentage of the number of treatment institutions equipped with road vehicles	5	-	4	-	-	-
Efficiency						
Average road vehicle unit price (K hrn)	760.0	-	825.0	-	-	-
Quality						
Percentage of provision with road vehicles, %	100.0	-	100.0	-	-	-

Source: Drawn up and calculated by authors according to the internal documentation of the med. institution.

The CNE "CPMSC" of the VTC elaborated the Strategic Priorities for Development for 2021–2023 (fragment is presented in Tbl. 22), with its respective financial support (Tbl. 23). In Fig. 44, grouping of strategic goals and priorities of development of the medical institution is visualized.

Table 22

Fragment of Measures of Strategic Priorities of Development of the CNE “CPMSC” of the VTC for 2021–2023

Strategic priorities	Implementation periods			Expected results	Strategic coordination
	2021	2022	2023		
I. Improvement of quality of services provided					
1.1. Equipping reception areas in 6 OCGPFMs		2	4	- growth in level of satisfaction of recipients of medical services according to the survey data by 15 %; - reduction in the number of patients’ complaints (by 20 %); - improvement of quality of provision of tele-medical services; - renewal of medical furniture and equipment by 75 %; - number of schools/institutions/visitors of schools of health (30/490/5,900, respectively)	Chief Physician, Chief Accountant, Deputy Chief Physicians
1.2. Establishment of the system of monitoring of satisfaction with institution services: conduct of patient questionnaire on quality of provision of medical services at structural subdivisions					
1.3. Carrying out of repair works (Dymer OCGPFM, FSs of the Liubymivka V. and Tolokun V.)	1	1	1		
1.4. Renewal of the material-technical base of subdivisions by procurement of new medical equipment and office furniture	17	14	11		
1.5. Development of tele-medical services at 18 OCGPFMs		18			
1.6. Establishment of schools of health	5/ 40/ 400	10/ 150/ 1,500	15/ 300/ 4,000		
II. Work with personnel					
2.1. Work with departments of family medicine of education institution of Kyiv C.	2nd half-year	2nd half-year	2nd half-year	- provision of staffing level on 100 %, relief of family physicians of part of work and establishment of staff pool; - provision with service housing	Chief Physician, Chief Accountant, Deputy Chief Physicians
2.2. Work with heads of bodies of local self-government in procurement (lease out on preferential conditions) of service housing for family physicians					
III. Improvement of financial efficiency					
3.1. Internal audit and optimization of organizational structure of institution				- increase in the % of the population of the raion in the “green list” until 2023 by 80 %; - increase in expenses per patient per annum (600.00 hrn); - +15 % to budget (NHSU) receipts from grants	Chief Physician, Chief Accountant
3.2. Attraction of grants for financing of innovative needs of institution		+5 %	+15 %		
3.3. Active information campaign for signature of declarations	+70 %	+75 %	+80 %		
IV. Reduction in level of morbidity of raion population with infectious diseases (incl. COVID-19)					
4.1. Reduction in morbidity with infectious diseases (incl. COVID-19) in raion by 15 %				- vaccination against common infectious diseases incl. COVID-19	Chief Physician, OCGPFM Manager
4.2. Fulfilment of plans of vaccinations against COVID-19	2nd half-year				
4.3. Cover of adult raion population by fluorography					

examination					
4.4. Broad explanatory work on infection with COVID-19 and necessity to conduct vaccination					

Source: Grouped by authors according to the internal documentation of the CNE "CPMSC" of the VTC.

Compliance with and performance of this strategy will enable to: increase the efficiency and quality of the provision of medical care in the primary link in order to overcome unfavorable demographic trends; increase a share of medical care provided: by general practice physicians – family physicians, on a family medicine basis at the level of outpatient-polyclinic care; form a system of the provision of the population with high-quality care on a family medicine basis; ensure the current maintenance, in the proper condition, of all structural subdivisions of the CNE "CPMSC" of the VTC, according to recommended lists of equipment and standards.

Table 23

Financial-Resource Support for Implementation of Strategic Measures of the CNE "CPMSC" of the VTC for 2021–2023

Amount of funds proposed to be applied for implementation	Performance years			Total costs (K hrn)
	2021	2022	2023	
Amount of resources, total (K hrn) incl.:	8,276.0	8,358.0	5,715.5	2,2349.5
Local budget	8,276.0	8,358.0	5,715.5	2,2349.5
Other sources (K hrn)	-	-	-	-

Source: Grouped by the author according to the internal documentation of the CNE "CPMSC" of the VTC.

Further, to fully detail the tools for the management of the activity of the CNE "CPMSC" of the VTC, we will conduct the SWOT analysis. It includes a holistic picture of the present situation with all positive and negative aspects. A conceptual approach is formulated so as to further optimize and effectively use strengths and remove, or, at least, reduce available weaknesses to a minimum [15].

A SWOT analysis enables to conduct a detailed study of the external and internal environment of the CNE "CPMSC" of the VTC that helps more effectively make strategic decisions. The purpose of using a SWOT analysis is to divide the factors and phenomena impacting the development of the hospital into four classic categories: strengths, weaknesses, opportunities and threats. Strengths show a competitive advantage of the CNE "CPMSC" of the VTC as compared to other medical institutions. Weaknesses are a set of internal factors braking its development. Opportunities include trends or events in the exogenous environment, responding to which the CNE "CPMSC" of the VTC can move to set goals faster. By threats is meant a set of factors, which might have a negative impact on the CNE "CPMSC" of the VTC, unless there is a respective response.

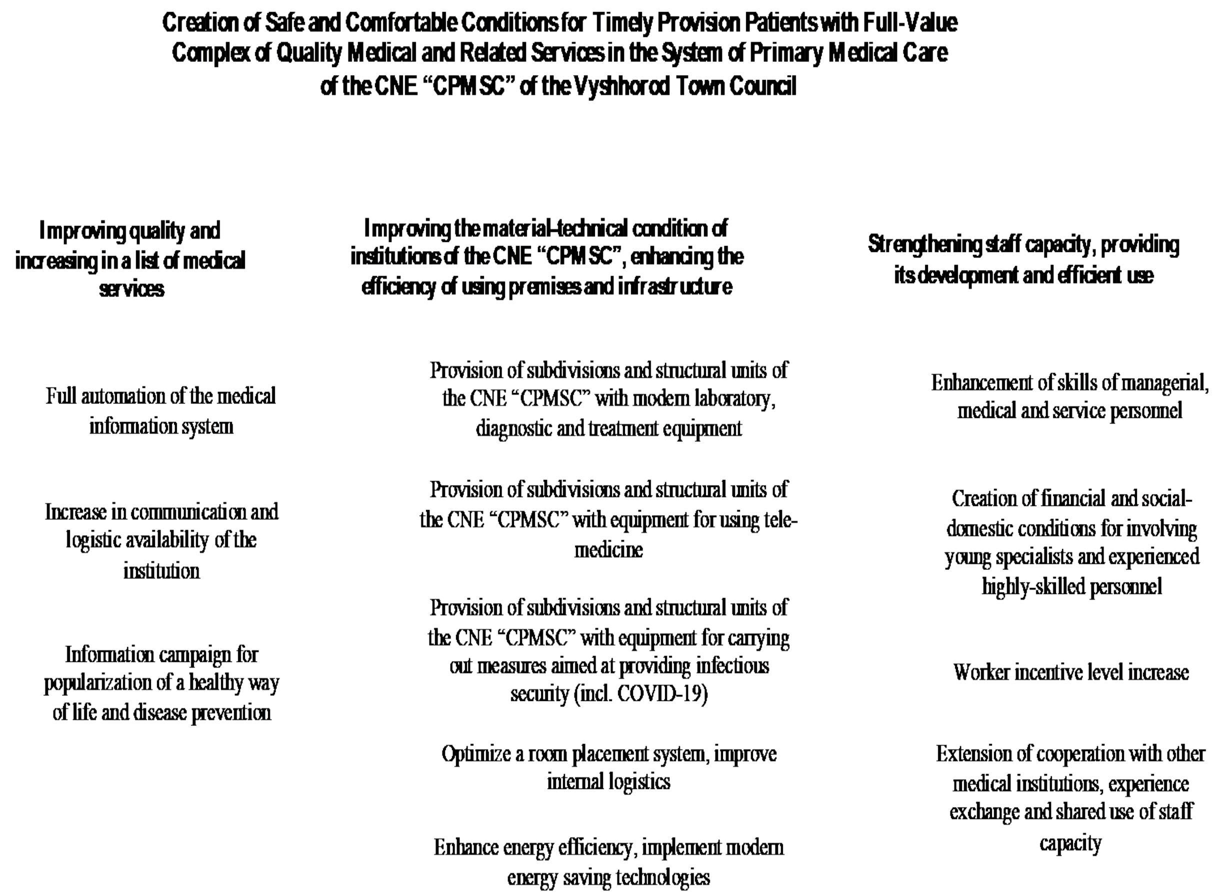


Figure 44. Aggregate Scheme of Strategic Priorities of Development of the CNE "CPMSC" of the VTC

Source: Grouped by authors according to the internal documentation of the CNE "CPMSC" of the VTC.

Certainly, studying endogenous (certainly, in relation to operation in the external environment) instruments in managing the activity of the CNE "CPMSC" of the VTC, as a whole, is impossible without assessing its competitive positions and, respectively, analyzing competitive forces according to M. Porter that impact, to one degree or another, the internal strategy for managing activity of the institution of healthcare. We presented these techniques using table parameters giving each parameter the respective rank reflecting a low, medium or high degree of a threat to the CNE "CPMSC" of the VTC. To assess an impact of each competitive force, it is enough to choose one of three assertions in the table and put the respective rank from "1" to "3". The respective ranking is summarized and the respective value is given. Intermediate results and some calculations are presented in Tbl. 24–28, the respective digital values are given in the tables.

Respective grouping of strengths and weaknesses, opportunities and threats for the CNE "CPMSC" of the VTC is presented in Fig. 45.

Strengths	Weaknesses
+ territorial availability of OCGPFMs and FSs; + compact and efficient structure of the primary medical care network; + availability of skilled specialists; + optimized staff of employees; + availability of developed local modern protocols of provision of medical care; + provision with computer and copy machines; + availability of road vehicles; + use of remote technologies to provide medical care from the distance; + capability to provide medical services to population of adjacent communities; + wish to advance and use modern management technologies; + established successful communications with the power; + use of mentoring and other forms of extension of best experience	– 20 % of family physicians are of retirement age – insufficient areas for receiving patients by physicians at some OCGPFMs and FSs; – insufficient quality of services through the poor material-technical base; – imperfect patients' appointment system; – absence of diagnostic departments at 75 % of OCGPFMs and FSs; – absence of service personnel for medical equipment inspections (metrology, calibrations); – excessive energy costs due to the absence of the energy audit and energy management system; – not energy-efficient premises of FSs; – obsolete electric power networks and other utility lines; – absence of fire alarms, incompliance of the technical base of the firefighting system with the requirements of the legislation at 60 % of OCGPFMs and FSs; – room furniture and equipment partly require modernization – absence of efficient information interaction between the subdivisions of the Center and different level hospitals; – not all specialists know modern diagnostic and treatment methodologies
Opportunities	**Threats**
⇒ active position and interest of the local power in medicine development; ⇒ financial capacity of communities of the Vyshhorod Raion; ⇒ satisfactory road condition; ⇒ territorial proximity to the capital of Ukraine; ⇒ involvement of youth (physicians after graduation of the internship and student apprentices) after graduation of the higher education institution; ⇒ developed social infrastructure for young families (availability of kindergartens, schools, out-of-school education institutions, houses of culture); ⇒ opportunity to participate in international grants; ⇒ incentive to participation of medical workers in conferences, trainings and other events of skill improvement upon the availability of sufficient financing; ⇒ available opportunity to study advanced experience (European countries and other cities of Ukraine)	# low level of culture of a healthy way of life; # COVID-19 pandemic; # Growth in the general level of population morbidity; # Ageing of population, worsening of social-demographic indicators; # High cost of lease of housing for young specialists; # Competition of family physicians with physicians of the secondary link (territorial proximity to private healthcare institutions of the capital); # Insufficient number of additional services, first of all, diagnostic services; # Insufficient level of infectious protection in the subordinated network of institutions

Figure 45. SWOT Analysis of the CNE "CPMSC" of the VTC

Source: Analyzed and grouped by authors according to the internal documentation of the CNE "CPMSC" of the VTC.

Table 24

Identification of Degree and Rank of a Threat from Substitute Goods (Substitute Services)

Assessment parameter for threat degree and rank identification	Parameter assessment		
	3	2	1
Substitute service	Exists and occupies a considerable market share	Exists, but their market share is small	**Does not exist**
Outcome	1		
1	**LOW THREAT OCCURRENCE LEVEL**		
2	Medium threat occurrence level		
3	High threat occurrence level		

Source: Calculated by authors according to [16].

Table 25

Identification of Degree and Rank of a Threat from Intra-Branch Competition

Assessment parameter for threat degree and rank identification	Parameter assessment		
	3	2	1
Number of market players	High player concentration	**Medium player concentration**	Low player concentration
Market growth rates	Absent or negative	Low	**High**
Price barriers	Though price competition in the market, there are no opportunities to raise prices	**There is an opportunity to raise prices only to cover production cost growth**	There is always an opportunity to raise prices
Outcome	5		
3	Low threat occurrence level		
4–6	**MEDIUM THREAT OCCURRENCE LEVEL**		
7–9	High threat occurrence level		

Source: Calculated by authors according to [16].

Table 26

Identification of Degree and Rank of a Threat from Medical Services Providers (Suppliers)

Assessment parameter for threat degree and rank identification	Parameter assessment	
	2	1
Number of providers of similar services	**Small number or monopoly**	Wide choice of providers of similar services in the raion
Resource limitation	Unlimitedness in volumes	**Limitedness in volumes**
Competition-related expenses	**Low losses**	High losses
Application priority for service providers	**High**	Low
Outcome	7	
4	Low threat occurrence level	
5–6	Medium threat occurrence level	
7–9	**HIGH THREAT OCCURRENCE LEVEL**	

Source: Calculated by authors according to [16].

Table 27

Identification of Degree and Rank of a Threat of Entry into Market by New Players (Competitors)

Assessment parameter for threat degree and rank identification	Parameter assessment		
	3	2	1
"Strong" brands with a high awareness and loyalty level	**Absent**	2–3	More than 3
Differentiation of product (service)	Low	Medium	**High**
Access to distribution channels	Open	**Requires moderate investments**	Limited
State interference level	Absent	**High**	Low
Branch growth rates	High	**Medium**	Stagnation (fall)
Outcome	10		
6	Low threat occurrence level		
7–12	**MEDIUM THREAT OCCURRENCE LEVEL**		
13–18	High threat occurrence level		

Source: Calculated by authors according to [16].

Table 28

Identification of Degree and Rank of a Threat from Medical Services Recipients (Consumers)

Assessment parameter for threat degree and rank identification	Parameter assessment		
	3	2	1
Share of recipients of a wide range of med. services	Over 80 % of services provided fall on few patients	50 % of services rendered fall on few patients	**Scope of med. services is evenly distributed between patients**
Share of recipients of a mon-range of med. services	**Services are unique, there are certain analogues**	Services are partly unique, there are certain analogues	Services are not unique, there are certain analogues
Services sensitive to quality and price	Patient will always move to a service with a lower price	**Patient will move to another service, in case of considerable difference in price and quality**	Patient is not sensitive to service price and quality
Consumers not satisfied with services existing in the market	Dissatisfaction of patients with key quality characteristics of a service	**Dissatisfaction of patients with secondary characteristics of a service**	Full satisfaction
Outcome	8		
4	Low threat occurrence level		
5–8	**MEDIUM THREAT OCCURRENCE LEVEL**		
9–12	High threat occurrence level		

Source: Calculated by authors according to [16].

In Fig. 46, the levels are presented, for the impact of the M. Porter's forces concerning the CNE "CPMSC" of the VTC. They are named in the classic interpretation [16]. As seen from this figure, the greatest impact on the exogenous factors of management of the marketing activity of the CNE "CPMSC" of the VTC is exerted by the following exogenous factors:

– consumers, that is, medical services recipients – patients;
– potential competitors (for example, private hospitals, private physician's offices, healthcare institutions of neighboring raions, etc);
– suppliers, that is, medical services providers – physicians.

So, for the CNE "CPMSC" of the VTC, an important managerial decision is to concentrate endogenous efforts on holding specialist physicians, providing them with decent working conditions, using advanced world's experience, whereon the instruments can be directed, of both external marketing, as consumer-oriented, and internal marketing, as oriented on the whole hospital personnel – from highly-skilled physicians (primary and secondary link physicians) to the service personnel (nurses, technical-service personnel).

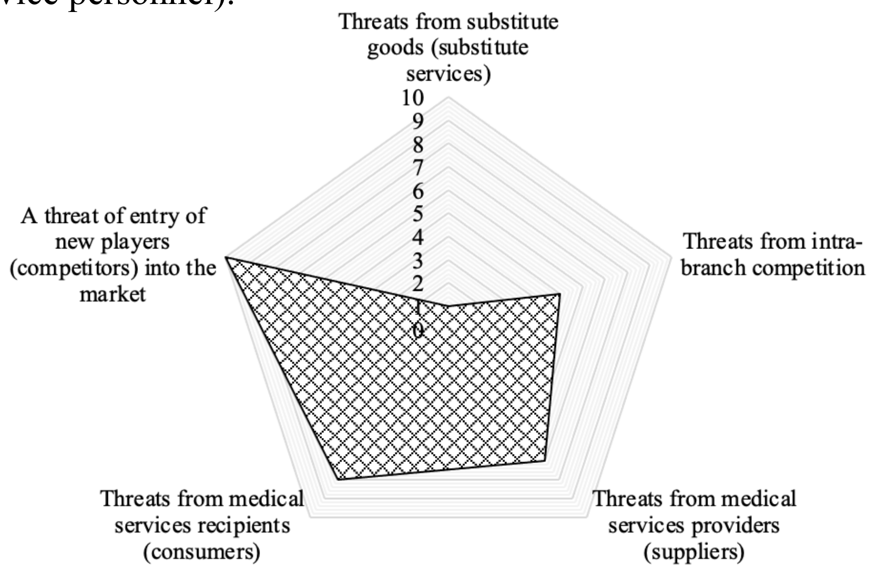


Figure 46. Porter's Pentagon for the CNE "CPMSC" of the VTC

Source: Visualized by authors according to tbl. 6–10.

Accordingly, the least impact on endogenous factors for managing marketing activity of the CNE "CPMSC" of the VTC is exerted by a risk of the occurrence of a substitute good, that is, a substitute service, since is naturally impossible – the provision medical services is and remains a dogma phenomenon.

In view of the conducted analysis of the activity of the CNE "CPMSC" of the VTC by various aspects, the following key problems are identified, on the solution of which the management will need to focus strategic and tactical benchmarks, in order to provide institutional capacity of social institutions for cluster rural development: 1) an increase in the quality of the provision of medical services inside the agrarian-industrial cluster; 2) COVID test infrastructure and equipment; 3) the enhancement of staff capacity, the provision of its development and efficient use subject to the need of the cluster formation etc. But the main challenge, for today, and not for the medical system only, but also for the whole world is a COVID-19 pandemic and timeliness and readiness to conduct full-scale antivirus vaccination housed by specially equipped rooms at the institutions of the agro-industrial cluster.

Reforming social institutions of support for development of agro-industrial clusters is a quite complicated process, since hospitals remain a quite conservative element of the healthcare system, despite the new challenges and changes in the systems themselves. Functional activity of state healthcare institutions in the medical services market in the modern conditions has to regard to the endogenous and exogenous challenges associated with conducting a medical reform, rural economy decentralization and clustering processes, which should include: using new models of social-agrarian management; new methods of payment for medical services, strengthening control over their provision from the agrarian-industrial cluster's stakeholders; improving forms of planning and organization of activities of medical institutions, subject to the needs of the agrarian-industrial cluster; professionalizing staffing of medical institutions and medical workers of the agrarian-industrial cluster; innovating information-analytical support in terms of forming an electronic healthcare system; differentiating the sources of financial support for the provision of medical services, involving the stakeholders of the agrarian-industrial cluster in the formation of the financial resource; complying with the international standards for the quality of the provision of medical services, conducting the audit of the medical care quality and constant monitoring of the competitiveness of medical services.

Main advantages of the immediate improvement of the quality of the provision of medical services at the CNE "CPMSC" of the VTC, compliance with the strategic priorities of improving its work, subject to the needs of the agrarian-industrial cluster, are: formation of the team of specialists able to head the processes of continuous improvement of the quality at all social institutions (including medical institutions) of support for development of the agrarian-industrial cluster; formation of the endogenous environment, friendly to the patients, oriented on the constant monitoring of patients' satisfaction with the medical service quality; creation of respective conditions for timely introduction of new medical-technological documents based on the evidential medicine; ensuring implementation of the system of monitoring of medical care quality indicators set in medical-technological documents of the stakeholders of the agrarian-industrial cluster; compliance of the medical institution with the accreditation and certification criteria approved by the MOH of Ukraine and the internal regulation of the agrarian-industrial cluster; formation of the organizational culture and sustainable "face" of the institution open to continuous implementation of positive vectors of changes in improving the provision of medical care to the stakeholders of the agrarian-industrial cluster.

REFERENCES

1. President Of Ukraine (2019). Decree of the President of Ukraine "About the Sustainable Development Goals of Ukraine for the period up to 2030". Retrieved from: https://zakon.rada.gov.ua/laws/show/722/2019#Text (Last accessed: 20.08.2021)

2. Detsentralizatsiya. (2021). Ofitsiinyi sait pro detsentralizatsiiu [Decentralisation]. Retrieved from: https://decentralization.gov.ua/about [in Ukrainian].
3. The Verkhovna Rada of Ukraine (1990), The Law of Ukraine “On the priority of social development of the village and agro-industrial complex in the national economy”. Retrieved from: https://zakon.rada.gov.ua/laws/show/400-12#Text (Last accessed: 20.08.2021)
4. Khvesyk M. A., Ilina M. V. (2019). Parametryzatsiia otsiniuvannia perspektyv rozvytku silskykh terytorii riznykh typiv [Parameterization of assessment of prospects of development of rural territories of different types]. *Ekonomika APK*, 6, 6–14. DOI: 10.32317/2221-1055.201906006
5. Komunalne nekomertsiine pidpryiemstvo «Tsentr pervynnoi medyko-sanitarnoi dopomohy» Vyshhorodskoi miskoi rady. (2021). Ofitsiinyi sait Komunalnoho nekomertsiinoho pidpryiemstva «Tsentr pervynnoi medyko-sanitarnoi dopomohy» Vyshhorodskoi miskoi rady [Municipal non-profit enterprise “Primary Health Care Center” of Vyshhorod City Council]. Retrieved from: http://vyshgorod.cpmsd.org.ua [in Ukrainian].
6. Bodenchuk L. B., Radionova M. I. (2019). Pidvyshchennia konkurentospromozhnosti medychnykh zakladiv za dopomohoiu elementiv stratehichnoho menedzhmentu [Increase of Medical Institutions’ Competitiveness by Means of the Elements of Strategic Management]. *Black sea economic studies, 47-1*, 114–117. DOI: 10.32843/bses.47-20
7. Pashchenko V. (2016). Efektyvnyi vnutrishnii marketynh – zaporuka uspikhu medychnoho zakladu [Effective internal marketing is the key to the success of a medical institution]. *The practice of managing a medical institution, 3*, 64–71 [in Ukrainian].
8. Serzhuk A. V. (2015). Kompleks marketynhu na rynku okhorony zdorovia [The marketing mix at the market of health protection]. *Scientific Bulletin of Poltava University of Economics and Trade. A series of “Economic Sciences”, 2 (71)*, 23–28 [in Ukrainian].
9. Barzylovych A. D. (2020). Reformuvannia systemy okhorony zdorovia v Ukraini: stratehichni aspekty [Health System Reform in Ukraine: Strategic Aspects]. *Investytsiyi: praktyka ta dosvid, 2*, 134–140. DOI: 10.32702/2306-6814.2020.2.134
10. Haltsova O. L. (2020). Derzhavna polityka u sferi okhorony zdorovia: pochatok druhoho etapu reformy [Public Health Policy: the Beginning of the Second Phase of Reform]. *Ukrainian Journal of Applied Economics, 5-2*, 101–107. DOI: 10.36887/2415-8453-2020-2-12
11. Ministerstvo okhorony zdorovia Ukrainy. (2021). Ofitsiinyi sait Ministerstva okhorony zdorovia Ukrainy [Ministry of Health]. Retrieved from: https://moz.gov.ua [in Ukrainian].
12. Decentralisation (2021). “Reforming medicine in the context of decentralization”. Retrieved from: https://decentralization.gov.ua/health [in Ukrainian].

13. Derzhavna sluzhba statystyky Ukrainy. (2021). Ofitsiinyi sait Derzhavnoi sluzhby statystyky Ukrainy [State Statistics Service of Ukraine]. Retrieved from: http://www.ukrstat.gov.ua [in Ukrainian].
14. Tsentr medychnoi statystyky MOZ Ukrainy. (2021). Ofitsiinyi sait Tsentru medychnoi statystyky MOZ Ukrainy [Center for Medical Statistics of the Ministry of Health of Ukraine]. Retrieved from: http://medstat.gov.ua/ukr/statdan.html [in Ukrainian].
15. Balabanova L.V. (Ed.) (2005). *SWOT-analiz – osnova formuvannia marketynhovykh stratehii* [SWOT-analysis - the basis for the formation of marketing strategies]. Kyiv: Znannia [in Ukrainian].
16. Porter M. (1998). *Stratehiia konkurentsii: metodyka analizu haluzei i diialnosti konkurentiv* [Competition strategy: methods of analysis of industries and competitors]. Kyiv: Osnovy [in Ukrainian].

V. «BLUE», «GREEN» AND DIGITAL TRANSFORMATION OF THE TRANSPORT SYSTEM

Dmytriieva Oksana
Doctor of Sciences (Economics),
Head of department of Economics and Business
Kharkiv National Automobile and Highway University
E-mail: oksanahnadu@gmail.com
ORCID ID 0000-0001-9314-350X

Shevchenko Inna
Doctor of Sciences (Economics),
Dean of Business and Administrative Faculty,
Professor of department of Economics and Business
Kharkiv National Automobile and Highway University
E-mail: shevchenko.khnadu@gmail.com
ORCID ID 0000-0003-0758-9244

Dmytriiev Illia
Doctor of Sciences (Economics),
Vice-rector for scientific work,
Professor of department of Economics and Business
Kharkiv National Automobile and Highway University
E-mail: idmiitriyev@gmail.com
ORCID ID 0000-0001-8693-3706

Levchenko Yaroslava
Doctor of Sciences (Economics),
Associate Professor of department of Economics and Business
Kharkiv National Automobile and Highway University
E-mail: slavalevcenko1984@gmail.com
ORCID ID 0000-0002-4979-1101

Transport system is an essential infrastructure for the economic well-being and growth of a country. A healthy transportation sector provides crucial support for economic growth in both rural and urban areas, national defense and sustained access to safe, efficient travel for the country's inhabitants.

It is clear that innovation (including "blue" and "green" digital transformation) in the transport sector is becoming extremely important.

5.1. Innovation development in transport infrastructure

Today, one of the key tasks of socio-economic development of Ukraine's economy and its equal and competitive partnership in the system of international trade and economic relations is to ensure the quality transformation of the country's existing transport infrastructure, which serves domestic transport and is an important participant of global logistics chains. The foundation of the expanded reproduction of the transport complex potential and its infrastructural component in the conditions of formation of the post-industrial economy is the timely introduction of advanced innovative technologies on the basis of efficiency and systematic approach.

Currently, infrastructure is an integral component of any economic system. As a result, infrastructure is a priority along with other processes. The emergence of infrastructure is preconditioned by the objective processes in the differentiation of labor and specialization of production and economic activities of economic entities and is the result of structural changes in the economy, which necessitated the creation of a certain system that reconciles the results of the differentiation of labor and structuring and compensates for the costs of production separation.

The emergence of the term “infrastructure” in the economic literature, according to a number of Western economists (A. Youngson, P. Samuelson, etc.), refers to the period of the 40's of the twentieth century and is associated with the names of such scientists as H. Singer, who used the term “overheadcapital” – “infrastructure”, and P. Rosenstein-Rodan, who introduced the term “infrastructure”, derived from the two Latin terms “infra” (“below”, “under”) and “structura” (“structure”, “location”) to denote “a set of general conditions that ensure favorable business development in key sectors of the economy and meet the needs of the population” [1]. Later, from the early 1960's, foreign and, from the late 1960's domestic economists, studied not only the economic nature of infrastructure, but also the necessary proportions in the development of industrial and service branches. With the development of a market economy infrastructures began to be considered as a means of regulating the economy.

The different types of infrastructure were distinguished gradually, by separating the individual functions of the main industries. Thus, in the 70's production and non-production (social) infrastructures were distinguished [1; 2]. Later, such a classification persisted [3], and some authors considered the institutional infrastructure in this context [4]. In turn, the production infrastructure is also subject to classification on the following grounds: spatial and production bases, sectoral principles of production construction, performance of functions. The production infrastructure is understood as a set of industries that provide conditions for the implementation of production processes. One of the components of this complex is transport.

When assigning an object to the infrastructure, it is necessary to determine the main criteria by which you can include the industry or the object in this set. The main criteria for classifying transport as production infrastructure are as follows:

1. Transport does not produce new products, but it is a continuation of the production process within the circulation process; it only moves products already created by other sectors of the national economy, thereby increasing their value by the amount of transport costs.

2. Transport products – transportation of goods and passengers – are inseparable from the process of transport production. It cannot be accumulated; its

stocks cannot be created. Therefore, the problem of reserves on transport consists in creating not the stocks of products, but the reserves of throughput and carrying capacity.

3. Transport products do not contain raw materials. Unlike industries, transport does not consume raw materials, but uses large amounts of fuel, electricity, lubricants and other materials.

4. The scheme of the capital turnover in transport differs from the turnover in industry and agriculture: the increase in capital is not in the form of goods, but only in monetary form.

5. In the transport market not the product in the form of a new thing is sold, but the production process of the transport complex. Thus, the requirements for the efficiency and quality of the transport system relate not only to its market products, the final results of transport activities, but also directly to the transport production process.

6. Problems of substantiating the essence and content of the concept of "transport infrastructure" are extremely relevant for the countries with turbulent economies, including Ukraine. The term "transport infrastructure" has only lately been used in the Ukrainian economy. This is not surprising, since the need for market-type infrastructure not only cannot develop, but cannot exist outside the market economy at all. At the same time, the unresolved problem of transport infrastructure in the economy science of Ukraine creates a lot of difficulties for economic practice, because it still lacks the system of reasonable recommendations for creating adequate infrastructure for Ukraine, taking into account both world experience and economic situation [4; 5].

Today transport, as the infrastructure of the national economy of Ukraine, is a specific sector of the economy, which participates in a single production and technological process of various industries, which fact affects the level of transport costs in the country and overall production efficiency. Since the transport sector is always associated with the general development of production forces, it is considered one of the most important components of the infrastructure of the economy as a whole. It is worth noting that the transport infrastructure occupies a special place and creates a kind of framework for the entire economic system of transport. The main purpose of the transport infrastructure is the implementation of the relationship between all functional elements in order to ensure the rational operation of these elements and the possibility of their spatial development.

The transport infrastructure facilities include railways, tramways and inland waterways, contact lines, highways, tunnels, overpasses, bridges, railway stations, bus stations, subways, airfields and airports, communication systems, navigation and traffic control systems, as well as those that ensure the functioning of the transport complex – buildings, structures, devices and equipment.

In conditions of economic growth and strengthening of integration processes, the role of transport infrastructure grows, as well as the role of its complex development and interaction of all subsectors, interrelation with other components of economy and social sphere of regions. Therefore, the solution to the problems of creation, functioning and development of transport infrastructure should be paid more attention as it is one of the components of increasing efficiency of production activities of economic entities, social development, improving quality of life, and, accordingly, the socio-economic development [6].

The concept of "transport infrastructure" has long been established in economic theory and practice. To date, this concept has been reflected in legislation. Thus, the Law of Ukraine "About Transport" devotes a section to the country's transport system. "The transport system is a transport and road complex consisting of: branches of transport, urban electric transport, departmental transport, pipeline transport, industrial railway transport, individual transport, public transport routes" [7]. In addition to this definition, it is clarified that the transport and road complex may include infrastructure to provide a set of services related to the transportation, among them the non-core ones.

Transport infrastructure provides regional connectivity, freedom of movement for citizens, promotes socio-economic development of both a particular territory and the state as a whole.

Transport infrastructure is important in solving socio-economic problems, participating in the creation of goods produced by enterprises, and forming their final value, making the territorial accessibility of social facilities, ensuring transport mobility of the population and thus making a direct contribution to gross domestic product through implementation of the functions assigned to this type of infrastructure (Fig. 47).

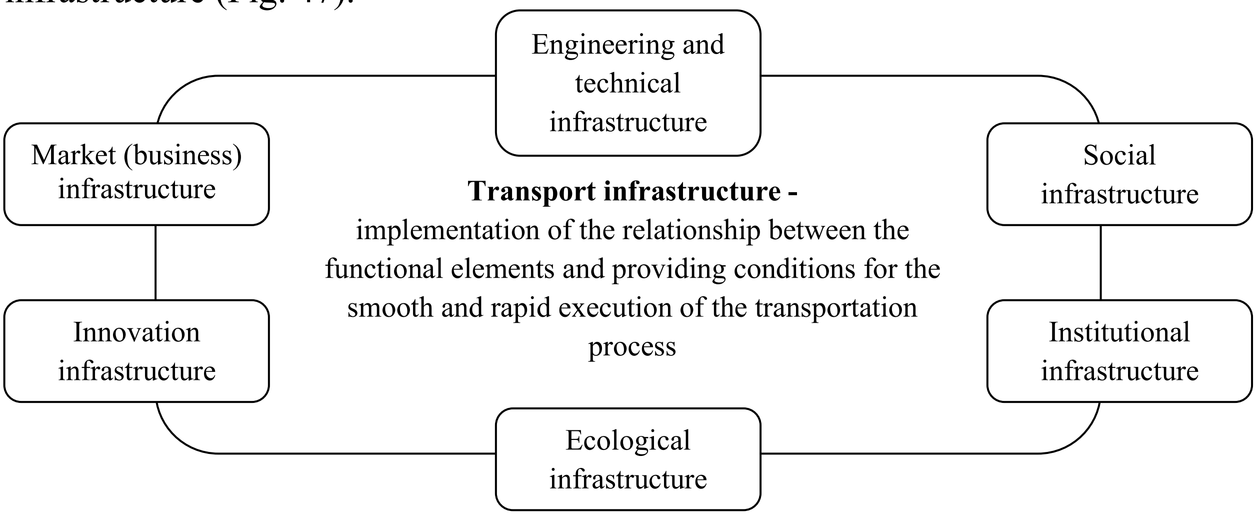


Fig. 47. **The place and role of transport infrastructure in economic development**
Source: Formed by the author according to sources [8; 9]

Since the transport complex covers the operation of a number of facilities that are not directly involved in the process of providing transport services, but indirectly affect the formation of effective conditions for its conduct, the composition of transport infrastructure should be represented by the following elements (Fig. 48) [10]:

1) transport services: transport routes of all types of transport, bridges, tunnels, ferries, vehicles, facilities, traffic control devices, stations, control points and

other means, buildings and complexes that are directly involved in the transport process;

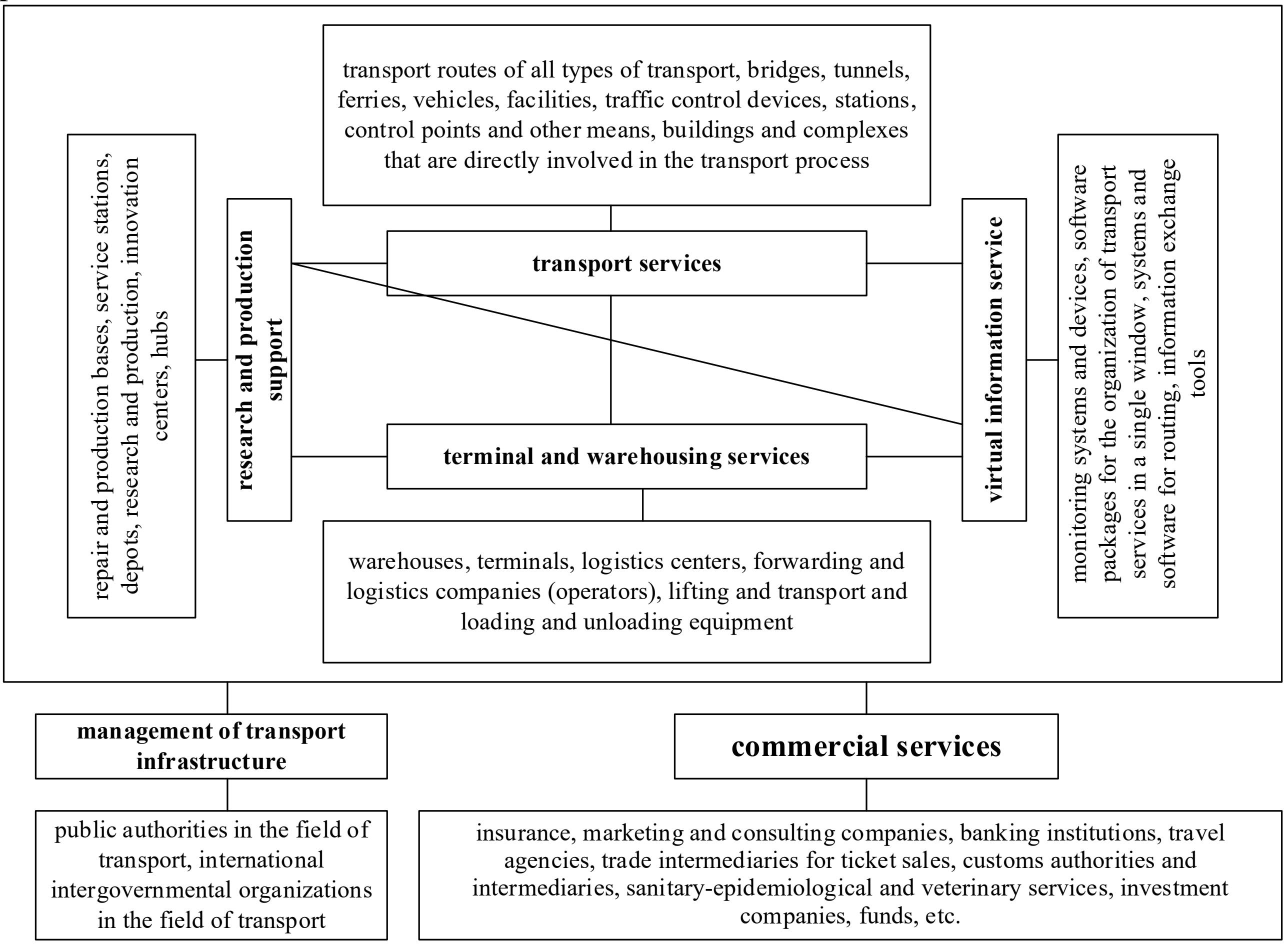


Fig. 48. **Components of transport infrastructure**
Source: Author's development

2) terminal and warehousing services: warehouses, terminals, logistics centers, forwarding and logistics companies (operators), lifting and transport and loading and unloading equipment;

3) virtual information service: monitoring systems and devices, software packages for the organization of transport services in a single window, systems and software for routing, information exchange tools;

4) research and production support: repair and production bases, service stations, depots, research and production, innovation centers, hubs;

5) management of transport infrastructure: public authorities in the field of transport, international intergovernmental organizations in the field of transport;

6) commercial services: insurance, marketing and consulting companies, banking institutions, travel agencies, trade intermediaries for ticket sales, customs authorities and intermediaries, sanitary-epidemiological and veterinary services, investment companies, funds, etc.

Today transport infrastructure is one of the most dynamically developing activities. In particular, the factors of global influence that determine the trends of innovative development of transport infrastructure include the following [11]:

- technological: Industry 4.0; smart infrastructure; robotic complexes; digital transportation management technologies; digital services; digital transport corridors, including high-speed traffic infrastructure; additive repair technologies; resource and energy saving technologies; creation of branch localized productions, etc.;
- innovative: European Research Area for Innovation and Social Issues (“Open Innovation”, “Open Science”), European cloud initiatives; industry infrastructure for innovation; intellectual and communication platforms of innovation cooperation; global database of innovations, etc.;
- investment: international investment institutions; global / international investment aid programs; development of project financing, including growth of the share of public investments within the PPP; specialized investment zones, etc.;
- personnel: intellectualization of labor; digital workplace; virtual / electronic learning systems; unification of professional standards; international research and production migration; knowledge culture and social responsibility;
- institutional: deepening of international trade and economic cooperation; European Digital Agenda; global projects of infrastructure and technological cooperation; unification of norms and standards; liberalization of the market of transport infrastructure services, etc.

Among the factors that have a local impact on the processes of innovative development of transport infrastructure of Ukraine, we should highlight the following:

- technological: digital modernization of transport infrastructure facilities, including the rolling stock; construction of robotic terminals and warehouses; comprehensive renovation and modernization of repair bases; creation of an integrated system of interaction of transport infrastructure objects;
- innovative: development of sectoral innovation infrastructure, including State Fund for the Creation and Transfer of Transport Technologies; formation of an integrated environment for innovation management; creation of electronic services and industry base of innovations; formation of a digital platform for innovation cooperation and elaboration of a program for the development of strategic innovation cooperation, etc.;
- investment: competitive tariff and price policy; unified, transparent system of planning, attraction and use of investments in infrastructure projects; state guarantees and protection of investors' interests; investment program for the implementation of transport infrastructure development projects; simplification of project financing mechanisms, including public-private partnership during the implementation of transport infrastructure development projects;
- personnel: modern system of professional competence, personnel training and retraining programs; progressive system of remuneration; international internship programs; educational grants; branch program of social development of personnel; development of sectoral social infrastructure, etc.;

- institutional: implementation of European norms, standards and regulations in domestic transport legislation; completion of reforms and formation of a competitive market for transport infrastructure services; strategy of digital modernization of transport infrastructure; service platform for regulating the processes of innovative development of transport infrastructure; anti-corruption program; program of state stimulation of innovative development of transport infrastructure; transparent mechanism of coordination and monitoring of the state management of transport infrastructure, etc.

The processes of globalization and digitalization have led to innovative transformations in the global transport infrastructure, which are manifested not only in the introduction of robotic and intelligent technologies in the transport and logistics complex, but also in the formation of integrated information platforms within the global supply chains. The following patterns testify to innovative changes in the global transport and logistics space most explicitly.

First, the key regularity of the current stage of transport infrastructure development is the intensification of infrastructural strategic cooperation of countries and creation of infrastructure zones for economic cooperation, which have contributed to the formation of new transport corridors and comprehensive modernization of transport and logistics infrastructure. This is evidenced by the large-scale projects implemented in a number of countries in the line of expanding the transport links and deepening the trade and economic cooperation. After all, it was the deepening of economic cooperation between China and the EU and, accordingly, the intensification of trade flows in this direction that stimulated the expansion of the transport infrastructure capacity.

Secondly, the scale of the initiated projects for the development of global transport infrastructure has led to the transformation of traditional mechanisms for their financing. First of all, the structure of sources of investment funds has changed in the direction of increasing public expenditures on financing infrastructure projects, in particular through the simplification and unification of public-private partnership mechanisms.

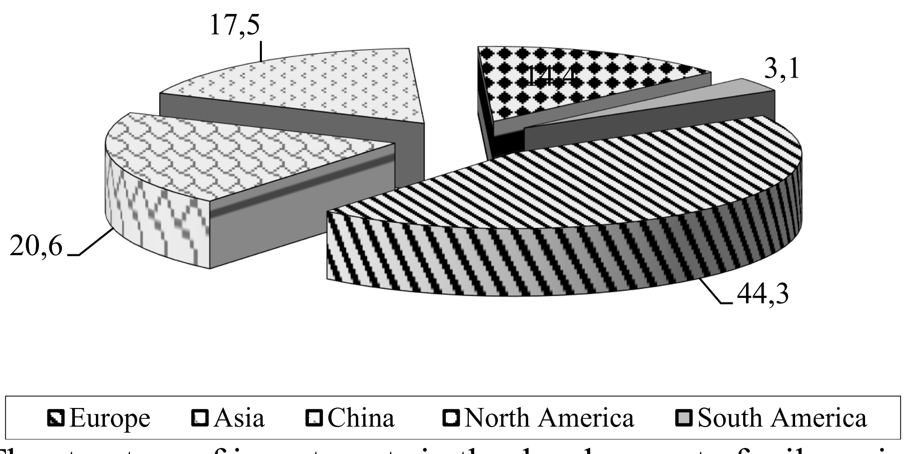


Fig. 49. The structure of investments in the development of railway infrastructure, %
Source: Formed by the author according to sources [12]

Considering the geography of countries' investments in the implementation of transport infrastructure development projects (Fig. 49), it should be noted that most investments (44.3%) in transport development are made by European countries, whose total investments in infrastructure projects amount to more than $ 200 billion. The countries of Asia and the Pacific region occupy the second place in terms of investment in the development of transport infrastructure; they account for 20.3% of world investment, while China alone has invested almost 79.1 billion dollars [12].

At the same time, the share of international financial institutions in financing transport infrastructure development projects has significantly increased. In particular, $ 34 billion of infrastructure investments has been allocated by international financial institutions to ensure the innovative development of the infrastructure of the Central Asian Regional Economic Cooperation (CAREC) countries, of which 75% ($ 25.5 billion) were invested in transport infrastructure. The largest donor in CAREC infrastructure development projects was the Asian Development Bank, which allocated a total investment of $ 12.5 billion. A significant part of infrastructure projects were financed by the World Bank, which invested $ 7.4 billion, the Islamic Development Bank, which allocated $ 1.7 billion and the European Bank for Reconstruction and Development, whose investment amounted to 1.6 billion dollars [13].

Third, against the background of the creation of global supply chains and deepening economic integration of the countries, the formation of multifunctional transport-industrial zones (platforms) took place, where coordinated interaction of all participants in value creation is ensured. The China-Belarus industrial center "Big Stone" operates on this principle, where not only transport infrastructure facilities are concentrated, but also a powerful innovation center which specializes in the development of innovations in the field of mechanical engineering, chemistry, biotechnology and other high-tech industries [14]. Such transport and industrial sites are the basis of the German economy, which is the most powerful among the economies of European countries in terms of innovation development [15].

Fourth, under the influence of globalization processes, which in transport are accompanied by the creation of global transport and logistics chains and strengthening interaction of different modes of transport, the requirements for the technical and technological level of the transport process qualitatively increased. First of all, this applies to the requirements for the duration of transportation and the possibility of their "door to door" implementation. This was the impetus for the development of intermodal transportation, specialized high-speed roads (highways, high-speed railways) and produced a continuous improvement of the world's container fleet. For example, only in recent years the high-speed railways have been constructed at an unprecedented pace throughout the world, their length in 2018 was more than 20 thousand km, in particular in China the length was more than 10 thousand km [16]. Japan is one of the three leaders in the introduction of high-speed rail traffic, where in 2016 a new record was set at a speed of 603 km/h [17]. European countries such as Germany, France, Great Britain, Italy, Poland, Portugal, etc. are also actively implementing high-speed traffic development projects. It is worth noting that such heavy activity of a number of countries in the development of high-speed railway infrastructure has become possible due to large-scale capital investments, which are carried out by the latter in the framework of national strategies for the development of transport systems. In particular, according to the German banking group DVB, the total investment in the development of infrastructure for various modes of transport reaches more than 413 billion dollars a year, of which 113 billion dollars are investments in the construction of automotive infrastructure. At the same time, the total cost of implemented infrastructure projects, such as construction and modernization of railways, reaches $ 45 billion, and the renewal of rolling stock accounts for $ 25 billion. By the end of 2020, about $ 45 billion had been invested in railway infrastructure projects, most of which was involved in the development of railway infrastructure in Europe [12].

However, the most global trend in the development of transport infrastructure is the implementation of technological transformations, accompanied by the mass introduction of digital technologies in the field of transport. Blockchain, robotics, artificial intelligence, 3D printing and modeling, the Internet of Things are already quite actively implemented in various areas of transport infrastructure, which is the seventh trend in the development of transport infrastructure. The introduction of digital technologies in railway transport happens primarily through the development of high-speed intelligent railways, within which a communication and navigation platform for the organization of the transportation process in real time is formed. The initiative to create digital railways was first announced in 2017 by the Swiss Federal Railways as the part of the national industry program Smart Rail 4.0. The latter envisages the creation of an interoperable integrated architecture of a complex of advanced traffic control technologies, within which it will be possible to quickly plan the train schedule, identify their location and monitor the technical condition, as well as automatically train and robotize station work [18].

However, the introduction of digital technologies in railway transport is not limited by the formation of the technological base for the functioning of digital railways. Thanks to blockchain technology, users of railway services can pay for services virtually, monitor and identify the location of goods, as well as support online communication and document management with the service provider.

The digitalization of the automotive industry is also accompanied by the introduction of "intelligent" unmanned vehicles, electric vehicles, traffic management systems, and electronic driver safety technologies (electronic log devices (ELD)) [19]. As for the intelligent unmanned vehicles, despite further work on improving this targeted solution, Tesla company has now designed the first electric traction, equipped with the function of "autopilot". This type of digital vehicle will greatly facilitate the process of driving and allow transport companies to significantly increase efficiency by eliminating the "driver" factor. Concerning TMS transportation control systems, the functionality of the built-in information systems creates a possibility to increase the transparency of communications and the efficiency of supply routing processes [20]. In addition, thanks to artificial intelligence, 3D printing and modeling technologies, the process of vehicle maintenance has been significantly optimized. Thus, the inclusion of CAD technologies and 3D printing in the production process of cars has significantly reduced its duration, eliminating from the process those technological operations that are associated with the development of the model, and significantly cutting production losses. In particular, such technology is currently actively used both by giant automobile companies like “BMV”, “Ford”, “Volkswagen” and small automobile manufacturing companies, such as “Tucci Hot Rods”. It is estimated that the latest introduction of digital technology in the production of cars, namely the Ultimaker technology has tripled the speed of parts manufacturing and saved 90% of the cost of outsourcing [21].

Digital technologies are most actively introduced in the field of air transport, due to the high growth of passenger traffic and, accordingly, the increase in the amount of data processed during the passenger service. Airport operators implement digital transformation programs, investing in the projects aiming at the development of biometric technologies, blockchain technologies, VR, AR and cloud services, technologies for processing and analysis of big data, as well as the projects for creation of smart digital centers. Despite the fact that today less than half of the world’s airports have implemented leading digital solutions aimed at improving the safety and quality of passenger service, in general, the level of digitalization of the aviation industry is already more than 30%. According to experts, capital investments in digital infrastructure transformation projects at airports will increase due to the growing passenger traffic, by 2023 they will amount 4.6 billion dollars a year [22].

One of the key trends in the digitalization of the aviation industry is the transformation of traditional airports into so-called ecosystems – economic centers with a personalized technological environment for passenger service. Studying the processes of digital transformation of air transport infrastructure, it is necessary to dwell on the analysis of those key trends that are already actively occurring in the activities of airports. Due to the intensification of flows in the airspace, one of the key areas of digital transformation of air transportation is the modernization of ship traffic control systems and radio communications. In this regard, most of the world’s airports are currently actively implementing air traffic control technology ADS-B (Automatic Dependent Surveillance – Broadcast), which allows tracking the location of airplanes, monitoring their movement both within the airport and in the remote areas where radar activity is limited.

One of the most common digital technologies at airports is blockchain technology, which is used for biometric identification of passengers and cargo, as well as their interactive navigation within the airport. Robotic technologies are also widely used. In particular, in large international airports, robots already perform the functions of service personnel, accepting luggage from passengers at the entrances and conducting their registration and passport control. The most modern robotic terminal was opened in 2018 in Singapore; it is equipped with robotic face recognition technologies and innovative luggage scanners, which significantly accelerate the service process at the airport [23; 24].

Digital technologies are actively implemented in maritime transport. In particular, the Internet of Things and blockchain technologies are the most involved digital technologies. Thanks to the first, the remote control of the departure of ships from the port, automatic transition and docking became possible today, as well as the support of communications between participants in the supply chain. Blockchain technology in the maritime industry has made it possible to provide automated processing of cargo data, online monitoring of ships and visibility of the entire supply chain.

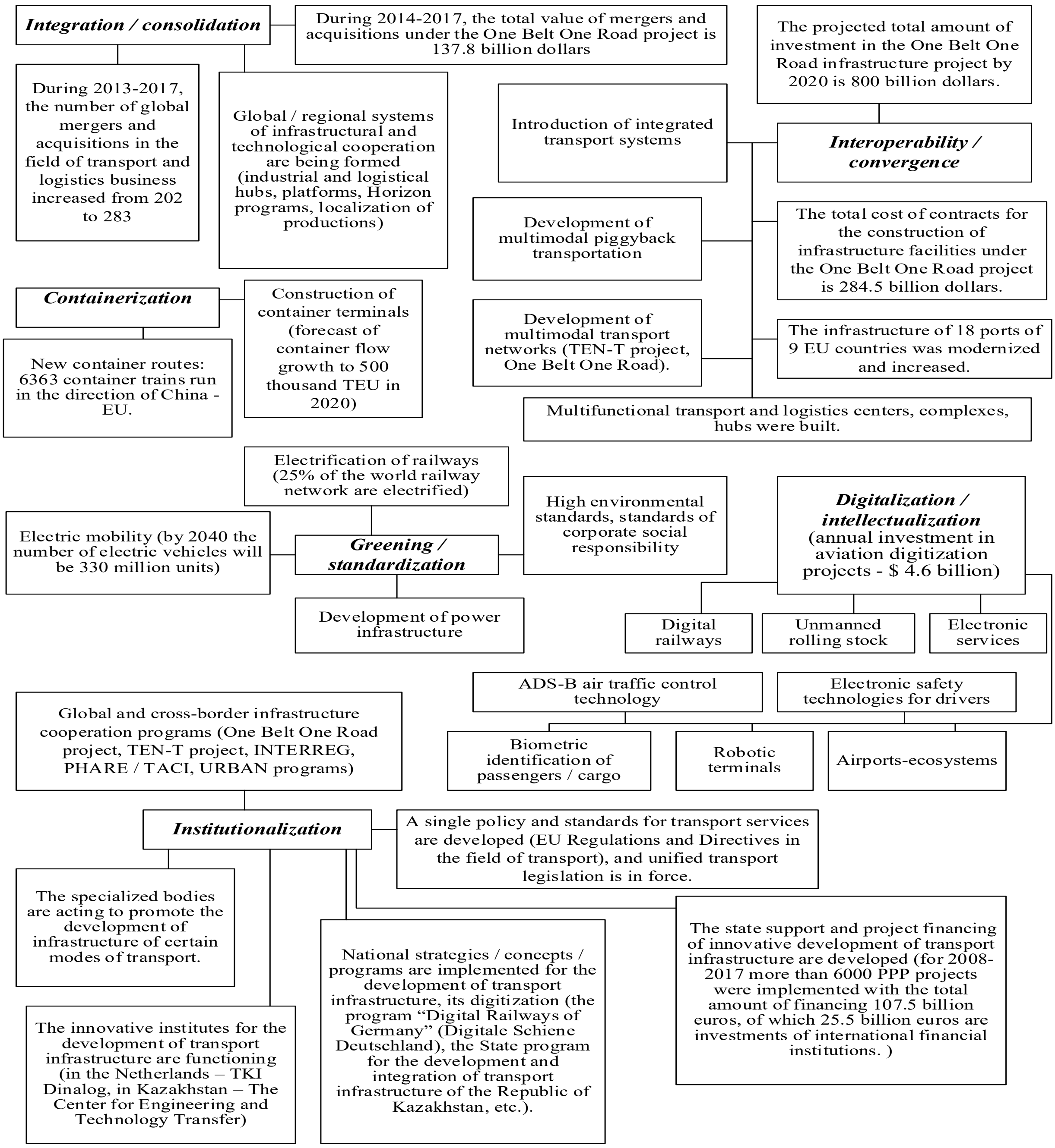


Fig. 50. **Trends in innovative development of world transport infrastructure**
Source: Author's development

The trends of transport infrastructure development described above have become possible due to the increased attention of states to the processes of transport complex transformation. In most economically developed countries, not only strategies and concepts for the development of transport infrastructure act at the state level, but also large-scale programs for their financing are implemented. In addition, the elaborated global policy for the development of transport systems and harmonized international standards of transport services testifies to the strengthening of the processes of state regulation of the market of transport infrastructure services.

Thus, summarizing in general, the following should be highlighted among the key trends in the innovative development of world transport infrastructure (Fig.50):

- integration and consolidation, which is manifested in the intensification of mergers and acquisitions in the transport and logistics business and the formation of global / regional systems of infrastructure and technological cooperation. Illustrative examples of the latest trend are those infrastructure initiatives related to the development of industrial and logistics hubs, platforms, as well as interstate innovation partnership programs, such as Horizon, and those that involve the creation of localized industries for infrastructure projects;
- interoperability / convergence which is manifested by the implementation of global transport infrastructure development projects aimed at maintaining interoperability, expanding capacity and accelerating and improving the quality of service in supply chains;
- containerization as a key direction of accelerating the delivery of goods;
- digitalization and intellectualization, which are expressed in the creation of digital transport systems and the formation of an intelligent environment for their interaction;
- greening and standardization are realized by the increase of ecological standards and standards of quality of transport service for consumers;
- institutionalization is expressed in increasing the attention of international institutions and public authorities to the projects of innovative development of transport infrastructure through the formation of innovative infrastructure to support their implementation and increase public funding of these projects.

5.2 Innovative transformation of the transport system: vector of environmental friendliness

Transport is integral with the globalization of the economy. Transportation is the basis for the formation of domestic and international markets, the development of the country's economy. The modern transport complex is subject to the conflicting trends: on the one hand, being an infrastructure industry, transport is dependent on the production of goods, on the other hand,it has a significant impact on the regional distribution of production capacity, it participates in the process of reproduction and is an important part of the system of economic relations.

The directions of development of integration processes in transport show in its integration with transport engineering and science – the level of scientific and technical progress directly determines the competitiveness of transport systems. At the same time, the following main areas are distinguished, where a decisive breakthrough should be expected: total informatization of transport, creation of economic and ecological "green" vehicles, creation of logistic transport and distribution systems.

The current state of development of social relations with the ever-increasing anthropogenic impact on the environment requires a change in the people's attitude to the processes of production and consumption of goods.

Thoughbeforethe very economic priorities were the basis of any human actions, today the ecology goals come to the fore. In other words, at the current stage ofthe transport systemdevelopment, every decision on innovative changes must be assessed from the standpoint of reducing the negative impact on the environment.

This approach is called greening of transport systems.

The processes of eco-destructive impact in transport are grouped in the following areas:

1. Automobile transport:
- emissions during the operation of car engines;
- noise ofautomobile transport;
- vibrations ofautomobile transport;
- electromagnetic radiation of cars;
- pollution by wear products of vehicles.

2. Automobile roads:
- extraction of local natural resources;
- change of terrain;
- hydroengineering works;
- technological pollution.

3. Railway transport:
- consumption of non-renewable natural resources during the operation of railway transport (petroleum products, water, air, etc.);
- low fuel efficiency;
- pollution of atmospheric air, water basins and soil by emissions and discharges due to the operation of mobile and stationary vehicles;
- pollution of the natural environment by various bulk cargoes during their loading, unloading and transportation, by garbage and waste of railway transport enterprises;
- environmental pollution due to the accidents during the transportation of environmentally hazardous goods.

4. Air transport:
- formation of the greenhouse effect and destruction of the ozone layer;
- emissions of harmful substances from the exhaust gases of aircraft engines;
- noise pollution from air transport.

5. Water transport:

- ballast water of tankers, transport and passenger vessels;
- spills of oil and oil products due to the accidents of transport vessels;
- oil-contaminated water from engine rooms, from washing of bunker and settling tanks, leakage during bunkering, especially in stormy weather;
- wastewater, household and industrial waste, chemicals, etc.

6. Pipeline: physical aging of the pipeline equipment; the need to replace hundreds of kilometers of main pipelines each year anddozens of gas pumping stations.

When burning 1 kg of gasoline each car uses 15 kg of air, in particular, 5.5 kg of oxygen. When 1 ton of fuel is burned, 200 kg of carbon monoxide is released into the atmosphere. Motor vehicles account for about 55% of total harmful emissions, including more than 200 different compounds, among them: carbon oxides, lead, nitrogen, formaldehyde, including aromatic carbohydrates, benzopyrene, carcinogens, including surfactants, with many mutagensinthem. Motor vehicles also have a negative impact on acoustic (noise) pollution on central highways. The results of acoustic measurements and sociological research show that the main source of acoustic pollution in the city is automobile transport.

About every second inhabitant of the city suffers from the noise created by it. At the same time, the source of significant noise is open areas of the subway and city trams. Vibration along subway lines causes harmful effects not only on the population, but on buildings as well. The situation around the construction of major highways is also complicated. During active construction, a large number of trees are cut down. Due to long-term construction and intensive anthropogenic impact on the ecosystem near the designed road, energy connections between living components within the system are lost.

The leading place in the transport complex is occupied by railway transport. Its share in the total volume of traffic is 24%. The length of railways is 22.8 thousand km. Their density is 38 km per 1,000 km^2. The densest network of railways is formed in Donbass, Dnieper, Western regions of Ukraine. All this significantly increases emissions into the environment during the transportation of passengers and goods. In addition, it is a source of noise pollution. Having an extensive river network, Ukraine is subject to significant anthropogenic impacts from water transport. River navigation covers almost all regions of the country and has prospects for future growth, so the operation of this transport should take into account the environmental component and minimize water pollution with oil and petroleum products, food waste, garbage and more.

Today, aviation in Ukraine is developing quite rapidly. The main problems in the development of air transport in Ukraine are the outdated fleet of aircraft, the actual lack of domestic traffic, the non-compliance of technical and environmental capabilities of airports in Ukraine with modern international requirements. Therefore, air transport is a source of violation of the acoustic regime in a large area, the state of air and groundwater.

Solving environmental problems in the transport sector of the country allows not only to significantly reduce the module of man-made load on the environment, promote the preservation of unique natural, historical and cultural landscapes, but also to significantly diminish the morbidity rate of the population.

In order to prevent and reduce air pollution by transport and other mobile vehicles and mechanisms and the impact of the related physical factors the following measures should be taken:

1. Conversion of transport and other mobile vehicles and mechanisms to less toxic fuels. The solution to this problem is possible through the production and introduction of new (alternative) types of environmentally friendly fuels, such as hydrogen.

Alternative fuels are all fuels that either do not contain petroleum derivatives at all or only partially contain refined products. Today, all alternative fuels are conventionally divided into four groups: extractive and associated gaseous fuels; synthesized and hydrolysis fuel; fuel from renewable resources; petroleum fuel with impurities;

2. Rational planning and construction of settlements with observance of normatively defined distance to transport ways;

3. Improvement of the condition of roads and pavement;

4. Withdrawal of transport enterprises, freight transit road transport from densely populated residential areas outside the city;

5. Restriction of entry for motor transport and other vehicles and mechanisms in settlements, resort, medical and health-improving, recreational and nature-reserve zones, places of mass recreation and tourism;

6. Improvement of fuel transportation and storage technologies, ensuring constant control over the fuel quality at oil refineries and gas stations;

7. Introduction and improvement of activity of control-regulating and diagnostic points and complex systems of checking the norms of ecological safety fortransport and other mobile vehicles and mechanisms.

Supporting the implementation of environmental standards today, road transport is moving to the use of electric vehicles, which in turn has led to the development of appropriate infrastructure for their maintenance and power supply.

According to the International Energy Agency, by the end of 2040 the number of electric vehicles that will be in operation on the world's roads will reach 330 million units, which will be more than 15% of the world's car fleet [25].

Even today, such countries as China, Japan, the Netherlands, and Denmark are actively switching to the use of electric cars. The largest number of electric cars (40% of the available fleet of vehicles) is currently operated in Norway, where the program of transition to environmentally friendly modes of transport is being implemented at the state level.

Electric cars also account for a significant share of the car market in Sweden, where their proportion reaches 6.3% [26]. The dynamics of the number of electric vehicles operating in the world during the period from 2007 to 2017 is presented in Fig. 51.

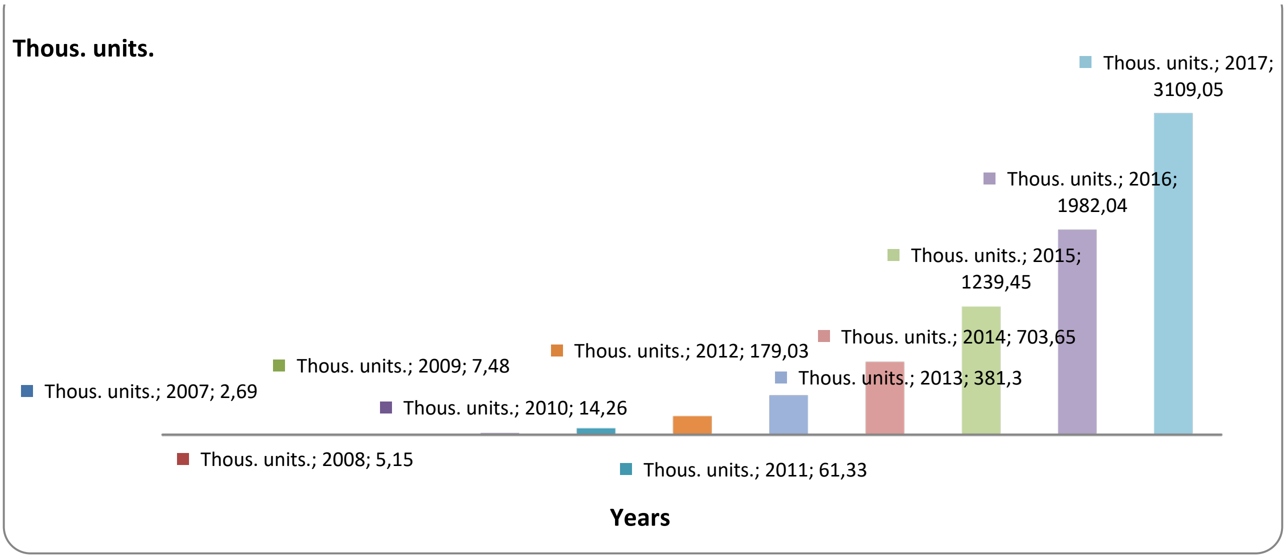


Fig. 51. Dynamics of the number of electric cars in operation in the world during the period from 2007 to 2017

Source: Developed by the authors based on [26].

All this indicates not only the implementation of projects for technological development of transport infrastructure, but also their focus on compliance with environmental standards. In this regard, the key regularity of the current stage of development of transport infrastructure is its sustainable greening. After all, against the background of the growing threat of the global environmental crisis, most countries focus on the introduction of common environmental standards of transport services through the transition of economical technologies and environmentally friendly modes of transport.

In rail transport, this trend is manifested in the increasing length of electrified railway lines: today more than 25% of the world's railway network is electrified, its length reaches almost 1 million km [27]. In road transport, the introduction of environmental standards is accompanied, as noted earlier, primarily by the introduction of electric rolling stock, as well as hybrid cars and cars on alternative fuels. Thus, in 2019, the Law "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the period up to 2030" was approved in Ukraine [28]. The aim of the state environmental policy is to achieve good environmental status by introducing an ecosystem approach to all areas of socio-economic development of Ukraine in order to ensure the constitutional right of every citizen of Ukraine for a clean and safe environment, to introduce sustainable use, preservation and restoration of natural ecosystems. The main principles of state environmental policy are:

- maintaining the state of the climate system, which will make it impossible to increase the risks to human health and well-being and the environment;
- reaching by Ukraine the Sustainable Development Goals (SDGs), which were approved at the 2015 United Nations Summit on Sustainable Development;

- promoting balanced (sustainable) development by achieving balanced components of development (economic, environmental, social), focusing on the priorities of balanced (sustainable) development;
- integration of environmental requirements during the development and approval of documents of state planning, sectoral, regional and local development and in the decision-making process on the planned activities of facilities that may have a significant impact on the environment;
- intersectoral partnership and stakeholder involvement;
- prevention of emergencies of natural and man-made nature, which involves analysis and forecasting of environmental risks based on the results of strategic environmental assessment, environmental impact assessment, as well as comprehensive monitoring of the environment;
- ensuring environmental safety and maintaining ecological balance on the territory of Ukraine, increasing the level of environmental safety in the exclusion zone;
- ensuring certainpunishment for violations of environmental legislation;
- application of the principles of caution, prevention, priority of eliminating the sources of environmental damage, "polluter pays" principle;
- responsibility of executive authorities and local governments for the availability, timeliness and reliability of environmental information;
- stimulation at the state level of domestic economic entities that reduce greenhouse gas emissions, lessen energy and resource intensity, modernize production aiming at minimizing the negative impact on the environment, including improvement of the green tax system for environmental pollution and fees for the use of natural resources;
- introduction of the up-to-date means and forms of communications and effective information policy in the field of environmental protection.

According to this strategy, the greening of transport provides [28]:

- development of environmentally friendly modes of transport;
- implementation of innovative projects aimed at reducing the level of noise pollution;
- optimization of traffic on the territory of large cities, further development of public electric transport;
- support for the use of vehicles that meet European standards;
- severization of the requirements for environmental safety and reliability of pipeline transport;
- harmonization of plans for development of the transport structure with the requirements, principles and priorities of the development of the ecological network, inexhaustible use, reproduction and conservation of bio- and landscape diversity;
- stimulation of the use of alternative fuels.

The main measures for greening of road transport are:

- increasing the efficiency of car engines
- introducing alternative drive mechanisms;
- enhancing the design of cars;

- improving fuel quality and reducing the toxicity of exhaust gases;
- assigning traffic flows and cutting the number of cars;
- accelerating the traffic flow;
- rational driving;
- influencing the traffic light mode.

The main measures to reduce the negative impact of roads on the environment are:

- noise reduction around stationary storage sites for road construction machines and mechanisms.

The following measures are used for greening on rail transport:

- construction of new gas boilers and conversion of existing ones to gas fuel;
- introduction of modern gas cleaning systems for boilers and production equipment;
- introduction of modern dust collection systems from the main production equipment and boiler houses;
- construction and reconstruction of ventilation systems of workshops and boiler-houses, introduction of filter-ventilation units;
- introduction of equipment for trapping heavy metal oxides;
- technical re-equipment of workshops, replacement of technological processes with more ecological ones; introduction of automated control and regulation systems for the concentration of harmful substances in the air;
- change-over of passenger trains to electric heating; electrification of railways;
- improvement of current and introduction of new more economical locomotives, replacement of traction power supply devices with environmentally friendly ones, etc.

The following steps are appropriate for the greening of the aviation industry:

- popularization of standards ISO 14000;
- popularization of the basic principles of ecological audit of enterprises;
- training of auditors;
- development of the regulatory framework for environmental audit;
- introduction of the national system of ecological certification.

There are three main areas of reducing the negative impact of water transport, purification of polluted waters of seas and rivers, namely:

- mechanical removal of debris and oil films from the water surface;
- chemical effects on oil films;
- biological decomposition of pollution, biological cleaning by means of plants, using the living beings capable to catch and process water pollutants, microbiological method.

Reliability, environmental safety and reduction of breakdown rate of oil pipelines are provided at the expense of the following:

- timely diagnostics and overhaul of the linear part, tanks and equipment;

- technical re-equipment and reconstruction of technological equipment, automation systems of pumping stations, tank farms and remote control engineering of the linear part of the main oil pipelines;
- modernization of existing and introduction of new systems of automated control of operating condition and fire extinguishing.

Transportation is one aspect we cannot do without in this day and age. However, the current transportation systems come along with a wide range of problems including global warming, environmental degradation, health implications (physical, emotional, mental, spiritual), and emission of greenhouse gases. In fact, the transport sector attributes to 23% of the globe's greenhouse gas emission resulting from burning of fossil fuels. Out of the total greenhouse gas emissions, road transport takes up a lion share, 75% to be precise and this trend is projected to increase in the future if it continues unabated. All this puts lot of pressure on the national governments to devise policies to reduce greenhouse gas emissions as well as oil demands. Statistics learn that over 90% of all road transportation relies on oil. This figure almost goes hand-in-hand with the total global oil consumption, which stands at 60%. All these scenarios have caught the eyes of most governments and policies are being formulated to reverse this worrying trend of air pollution.

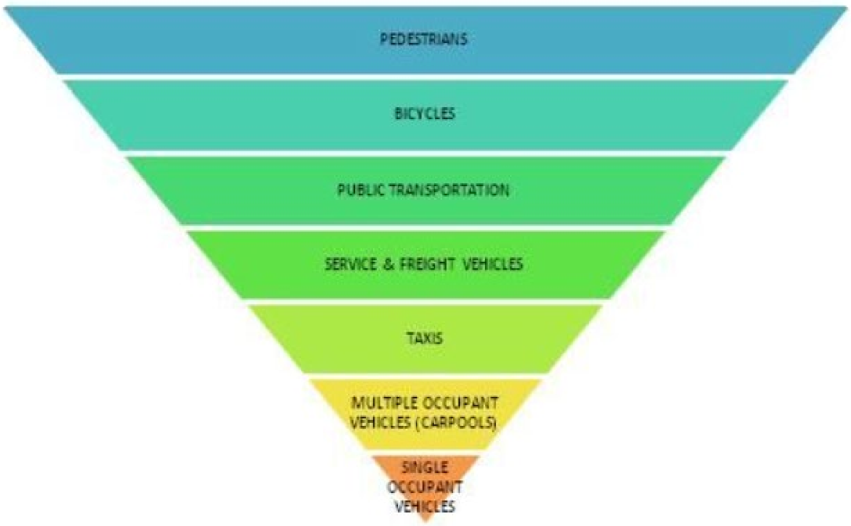


Fig. 52. Modes of green transportation

Source: [29]

In this campaign, transportation is the sector being targeted since it is the major contributor to greenhouse gas emission. The immediate and obvious solution to this wanton environmental pollution is greening of the transport sector, which suggests any sort of transportation vehicle or transportation habit that is environmentally friendly and doesn't emit toxic gasses that could impact the environment and human health. This leads to Green Transportation (Fig. 52), which means any kind of transportation practice or vehicle that is eco-friendly and does not have any negative impact on the immediate environment [29]. Green transportation revolves around efficient and effective use of resources, modification of the transport structure.

*Electrification.*The combined annual sales of battery electric vehicles and plug-in hybrid electric vehicles tipped over the two-million-vehicle mark for the first time in 2019 and staked a 2.5% share of all new car sales. Despite the impact of the global pandemic, the EV market is expected to rebound with continued growth.

Deloitte's global EV forecast (Fig. 53) is a compound annual growth rate (CAGR) of 29% achieved over the next ten years: total EV sales growing from 2.5 million in 2020 to 11.2 million in 2025, then reaching 31.1 million by 2030 [30].

*Fast Charging.*Electric Vehicles or EVs have become increasingly popular across the world and they are continuing to develop. Many of the available manufacturers today are looking to the future and are producing or planning to produce high-powered electric cars that can be easily comparable to some of the best fuel-powered vehicles. However, one of the standout features of electric vehicles or even hybrid vehicles is the ability to be powered by an in-built battery. These batteries are recharged through outlets either at home or anywhere there are charging outlets. All available EVs come with a regular AC charger that can normally take the battery from 0 to 100 percent in about 4-6 hours.

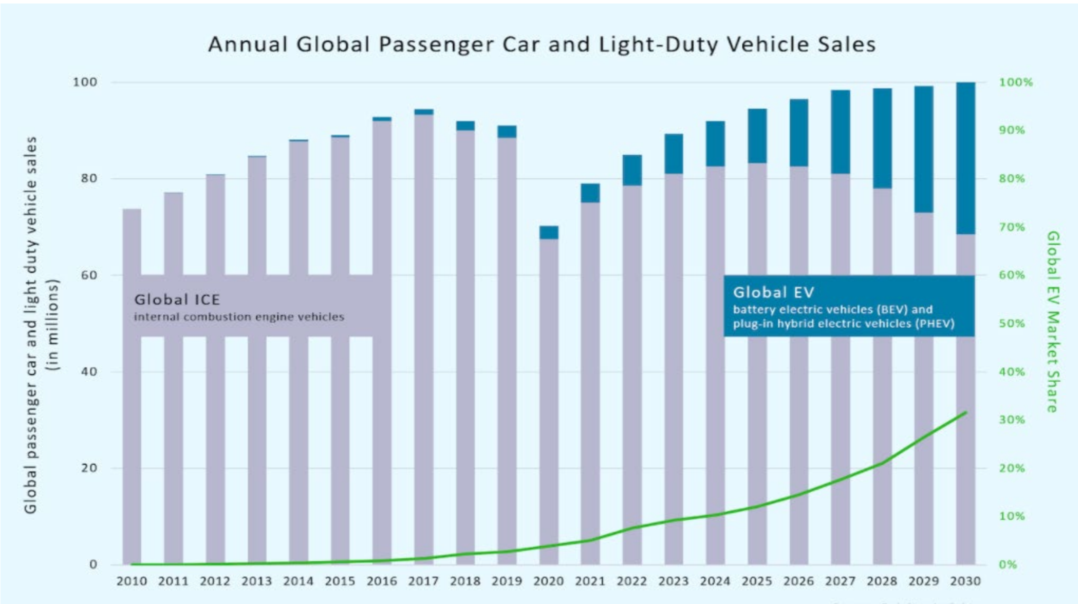


Fig. 53. Deloitte's global EV forecast

Source :[30]

But with the inclusion of fast charging, things have become extremely fast. So fast that the DC charger is capable of taking the battery from 0 to 80 percent in a matter of 30 minutes. While charging stations are quite rare right now, the increasing popularity of EVs is sure to build that number up [31].

*Self-driving electric buses.*Automated city buses and shuttles will be in operation in the near future. Autonomous vehicles use cameras, radars and GPS systems to recognize and communicate with traffic lights and have impressive safety records (Fig. 54).

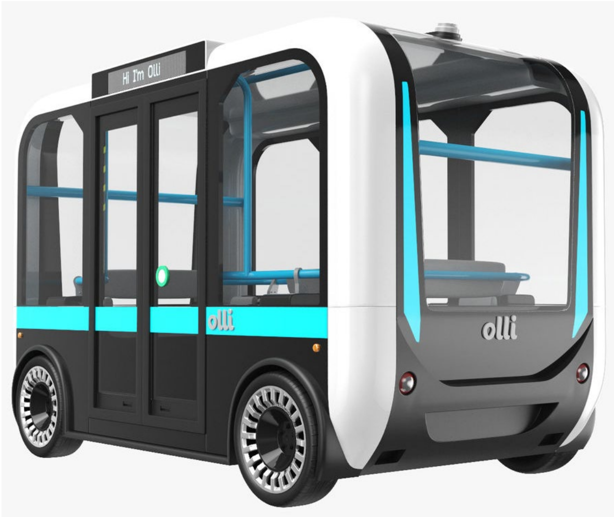


Fig. 54. Olli Bus Local Motors model

Source: [32]

These buses of the future will reduce the impact on the environment because Top 10 Latest Car Technology Innovations of The Past Decadethey are electric. Self-driving buses are already in operation in China and Germany, and are being tested in the U.S. Autonomous buses have a back-up mode where a human can take control of the vehicle if needed [33].

*Public transport tokens in exchange for plastic bottles.*The plastic-for-credits scheme is a one year trial that exchanges plastic waste for credit towards metro and bus rides in Rome. The service will be available at all three major stations: Cipro on the A line, Piramide on the B line, and S. Giovanni on the C line. Commuters will receive €0.05 for each plastic bottle donated. Thirty bottles are needed to cover a single-ticket, which is €1.50. The Government hopes that the initiative will also reduce Rome’s rubbish congestion in addition to preventing people from travelling without a ticket. While the program is amongst the first in Europe, a similar scheme was spotted in Surabaya, Indonesia last year − with ten plastic cups or five plastic bottles equating to a free two-hour bus ticket [34].

Special ticket-vending machines have been installed over the last years in the subway stations of Beijing (Fig. 55). As a way to raise awareness regarding plastic recycling, the machines accept used bottles as payment. Once entered in the recycling machine, the bottles are first scanned so that their value is calculated depending on the plastics’ quality and number (the estimated value of each plastic bottle is between 5 and 15 cents). In return, the machine issues a public transportation credit or extra mobile phone minutes. Most of them are placed in high-traffic or touristy areas, such as the Temple of Heaven, which sees as many as 60,000 people pass by daily.

Based on the same concept, similar vending machines have also been launched in Australia to help reduce the drink containers discarded each year (more than 160 million of them in NSW alone, making up almost half the volume of litter). Envirobank reverse vending machines (RVM’s) work the opposite way to a traditional vending machine, as by depositing an eligible container (plastic bottle or aluminium can), you receive a 10-cent refund credit. Their special feature is that they can hold up to 3,000 items as they immediately crush them. As a reward, users can select between food truck vouchers, tickets to the city’s famous New Year’s Eve party, and bus passes. The NSW's largest litter reduction scheme, named ‘Return and Earn’, started on 1 December 2017, and more than 500 collection points have been created to support this cause [35].

Fig. 55. Ticket-vending machines in Beijing's subway
Source: [35]

*Smart roads.*The road is often overlooked when discussing the future development and digital transformation of the modern transport infrastructure. Afterall, we have all heard of connected cars, self-driving cars, GPS navigation, route optimization apps and ride-hailing services. You would be forgiven for thinking how the common road fits into this digital revolution, as it turns out, the road itself can be a platform for an amazing array of innovations. Roads can be upgraded with communication, lighting and power transmission technologies that can support sustainability, improve safety and efficiency which in turn will help transform the driving experience.

Smart roads use Internet of Things (IoT) devices to make driving safer, more efficient, and in line with government objectives, greener. Smart roads combine physical infrastructures such as sensors and solar panels with software infrastructure like AI and big data. Smart road technologies are embedded in roads and can improve visibility, generate energy, communicate with autonomous and connected vehicles, monitor road conditions, and more [36].

Here are a few examples (Tbl. 29). Many governments and transport authorities understand the value of smart road technologies. However, developing smart city infrastructure at scale can be costly and complex. Leaders can break down smart road projects into phases, starting with low-investment, narrow-scale initiatives that can provide initial value, setting the stage for high-investment and large-scale efforts [36].

Table 29

Smart road technologies

Solar powered roadways	Photovoltaic cells are embedded within hexagonal panels made of tempered glass, which are used to pave roads. These panels contain LEDs, microprocessors, snow-melting heating devices and inductive charging capability for electric vehicles when driving. Glass is renewable and can be engineered to be stronger than steel, and to allow cars to stop safely even when traveling at high speeds. While this idea has gained widespread support, scalability is a challenge as it remains expensive.
Smart roads	Specially engineered roadways fitted with smart features, including sensors that monitor and report changing road conditions, and WiFi transmitters that provide broadband services to vehicles, homes and businesses. The smart road can also charge electric cars as they drive.
Glow in the dark roads	Glowing markers painted onto existing roadway surfaces use a photo-luminescent powder that absorbs and stores daylight. The 500m long strips glow for 8 hours after dark. This technology is still in the testing phase, and the glow is not yet consistent, but it could be more cost-effective than traditional road lighting technologies.
Interactive lights	Road lights activated by motion sensors to illuminate a particular section of the road as cars approach. The lights dim once the car passes. Suited for roads with less traffic, interactive lights provide night visibility as needed and reduce energy wastage when there are no cars. One design, developed in Holland, uses the wind generated by passing vehicles to power lights.
Electric priority lane for charging electric vehicles	Embedded cables generate magnetic fields that charge electric vehicles while driving. A receiver coil in the vehicle picks up electromagnetic oscillations from a transmitter coil embedded in the road and converts them to AC, which can then power the car. Inductive charging technology already exists for static cars, but future wireless technology could charge batteries while in motion, providing distance range solutions for electric vehicles which travel longer journeys.
Weather detection	Networks of AI-integrated sensors detect weather conditions that impact road safety. Road Weather Information Systems (RWIS) in use today are limited because they only collect data from a small set of weather stations. A larger future network could use automated weather stations to collect atmospheric and weather data and instantly upload it to the cloud. Dynamic temperature-sensitive paint could be used to highlight invisible roadway conditions like black ice.
Traffic detection	Data that helps travelers plan their routes. Sensors lining highways monitor traffic flow and weight load, warn drivers of traffic jams, and automatically alert the authorities about accidents. Fiber-optic cables embedded in the road detect wear and tear, and communication between vehicles and roads can improve traffic management. For example, rapid flow technologies use artificial intelligence (AI) to manage traffic lights, which respond to each other and to cars. Traditional systems were pre-programmed to optimize flow around peak journey times, new technologies are able to process and optimize flows in real time.

Source: [36]

5.3. Innovative transformation of the transport system: vector of safety

Traditionally, the safety of the transport system includes such elements (Fig. 56). Through the years there have been an enormous number of innovations in the automotive industry, including: the Ford Model T (1908), radios (1933), keys (1949), air conditioning (1953), seat belts (1958), electric windows (1960s), anti-lock brakes (1971), digital dashboard displays (1974), air bags (1974), on board diagnostics (1994), hybrid vehicles (1997), GPS satellite navigation (2000), advanced driver assistance systems (ADAS; 2010s), and autonomous driving (now and improving).

Today's evolving automotive market is being driven by several key areas of the safety innovations in the automotive industry (Fig. 57). Let's take a look at some of the latest developments from automakers to improve road safety.

Fig. 56. Elements of the transport system safety

Source: [37]

*Lane Keeping Assist.*This is one of the newest technologies incorporated into cars and the lane-keeping assistance feature is definitely one of the best ones yet. If you are used to long drives or driving through the night, the lane-keep assist helps you stay safe on the road at all times. The software in the car's system allows it to stay centered in the lane while driving forward.

This technology uses the steering along with the brakes to keep the vehicle within the lines of the driving lane and stops it from crossing them. As soon as the wheels begin to cross the lines, the lane-keep assistance technology kicks in and corrects it so that the vehicle stays centered and safe [31] (Fig. 58).

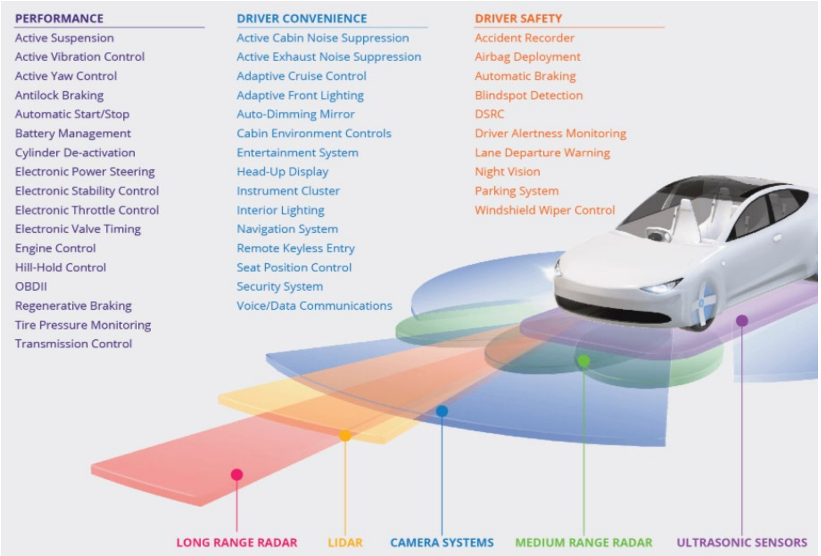


Fig. 57. Key areas of the safetyinnovations in the automotive industry
Source: [30]

*EyeDrive.*Device turns car windshield into display for Phones and Apps.France-based EyeLights created a portable device that converts car windshields into a hologram that displays phone functions and apps, like navigators. The hologram is projected on an eight-inch display that does not impair the driver's view of the road. The device, which is compatible with any vehicle, responds to hand gestures and voice controls. It was successfully crowdfunded on indiegogo.com in February and is available via the company's website.

1. Stay Aware

You may receive an alert − via a sound, flashing light or vibration − if you drift out of your lane.

2. Respond

Return to your lane. If you don't take action, this feature may gently steer you back to the center of the lane.

3. Engage

Slightly pulling the wheel will disable the lane keeping assist on most cars.

Fig. 58. Lane KeepingAssist

Source: [38]

EyeDrive improves safety by allowing drivers to use their smartphones without taking their hands off the wheel. According to the company, EyeDrive saves the user 4.3 seconds of reaction time, because the display is at eye level [34].

Automatic Emergency Braking. By reading the environment around the car, this automatic emergency braking technology can alert you when something is about to come in contact with the vehicle or block the driving path of the car. The sensors along with the on-board computer kick into action immediately and initiate the brakes which slow down or completely stop the car before it collides with the car, pedestrian, animal, or obstacle in the way (Fig. 59).

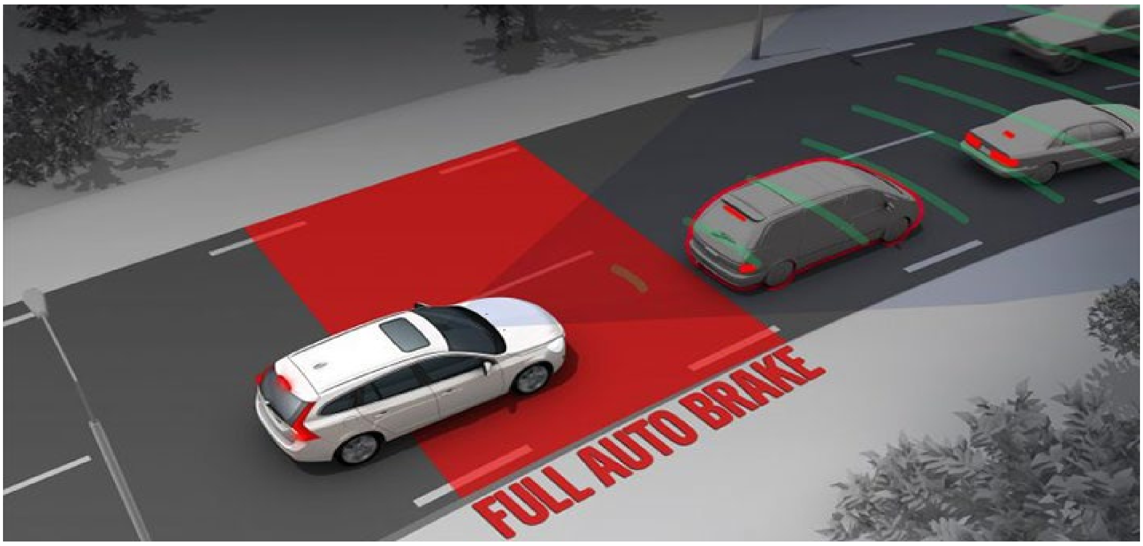


Fig. 59. Automatic Emergency Braking

Source: [31]

Automatic Parking. The automatic parking feature allows the driver to almost completely park their car automatically – except for the occasional brake when the driver is requested to do so.

Today, more and more car manufacturers have been including the automatic parking technology into their vehicles and the interested buyers have been going berserk for it (Fig. 60).

Automatic High-Beam control. A framework that naturally lights up and dims the high-beam headlights in connection to the moving traffic. A camera installed on the rearview mirror recognizes when the car is surrounding approaching traffic, and additionally vehicles ahead going a similar way, and withdraws the high beams [39].

*Biometric Seat Technology.*This innovation enables drivers to manage ordinary disturbances while driving, making the entire adventure more secure and comfortable. Biometric seat tech uses data from the driver’s face, and palm, joining it with real-time data gathered from the auto’s steering wheel, accelerator, clutch, and throttle to identify the driver’s anxiety and instructs him/her to take a break when required [39].

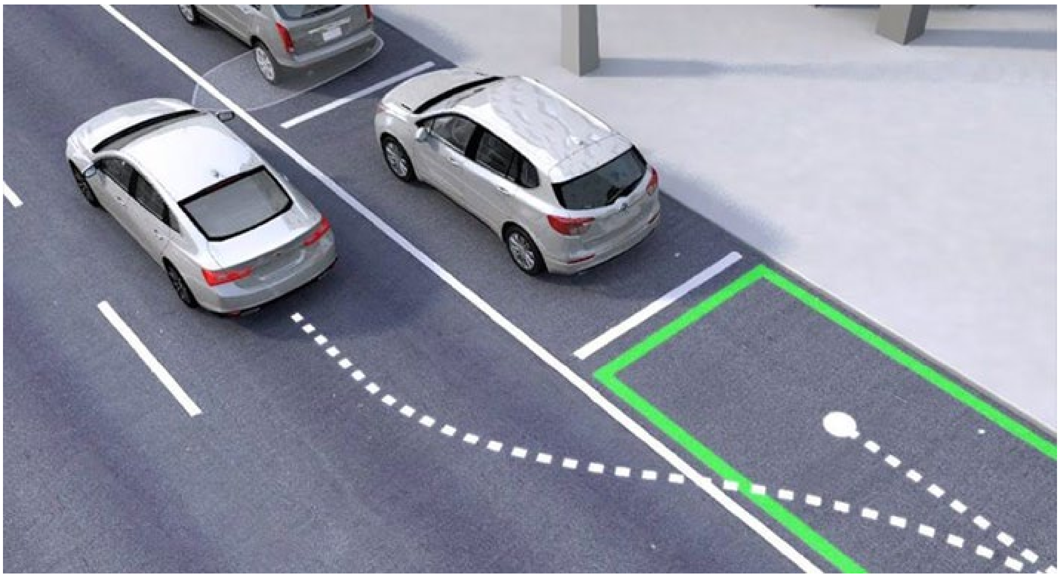


Fig. 60. Automatic Parking

Source: [31]

Fig. 61 represents standard functions of the Biometric Seat Technology, fig. 6.15represents the extended functions of the Biometric Seat Technology. But the perfection of car systems still can not fully prevent road accidents: no less important is the perfection of road infrastructure and driver training.

*Ground level pedestrian lights.*There has been a rise in the number of accidents involving foot traffic since the use of smartphones has increased. An innovation in transportation technology is a system that can be installed at pedestrian traffic lights that would light up the pavement in red or green to signal when it is safe or not safe for pedestrians to cross the street safely [33].

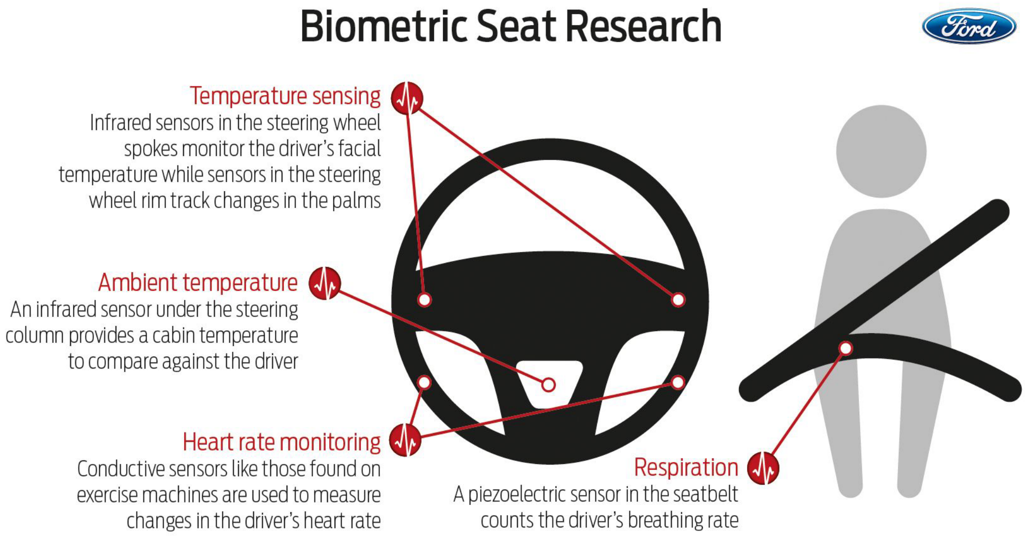


Fig. 61.Standard functions of the Biometric Seat Technology

Source: [40]

Fig. 62. Extended functions of the Biometric Seat Technology
Source: [41]

*Virtual reality training program helps improve road safety.*UK and Hungary-based Francis Kodak Design Lab created a virtual reality (VR) immersion safety course for drivers. The product, Another Set of Eyes (ANET360), combines traditional driver training methods with VR to teach better safety skills. It is the latest example of using total immersion technology to improve learning retention. ANET360 puts students in real-life situations and hypothetical scenarios. Once hooked into the headset, the student is immersed in a 360-degree experience. The training course is based on situations every driver faces. It can also be tailored to client demands. The program has improved driver reaction time by 20 per cent and reduced training costs by 50 per cent. The program also uses machine learning, which allows it to record user reactions across an unlimited number of scenarios [34].

Despite the constant improvement of practical training of drivers, the number of adherents of the autonomous driving is increasing. *Autonomous Driving.* There are five levels in the evolution of autonomous driving (Fig. 63).

Over the past few years, we've seen increased adoption of level 1 ADAS, including improved lidar distance sensing, lane departure controls, blind side detection, adaptive cruise control, and improved camera sensors. Automotive manufacturers currently produce vehicles at level 2 and many manufacturers are demonstrating (some) functionality of level 3.

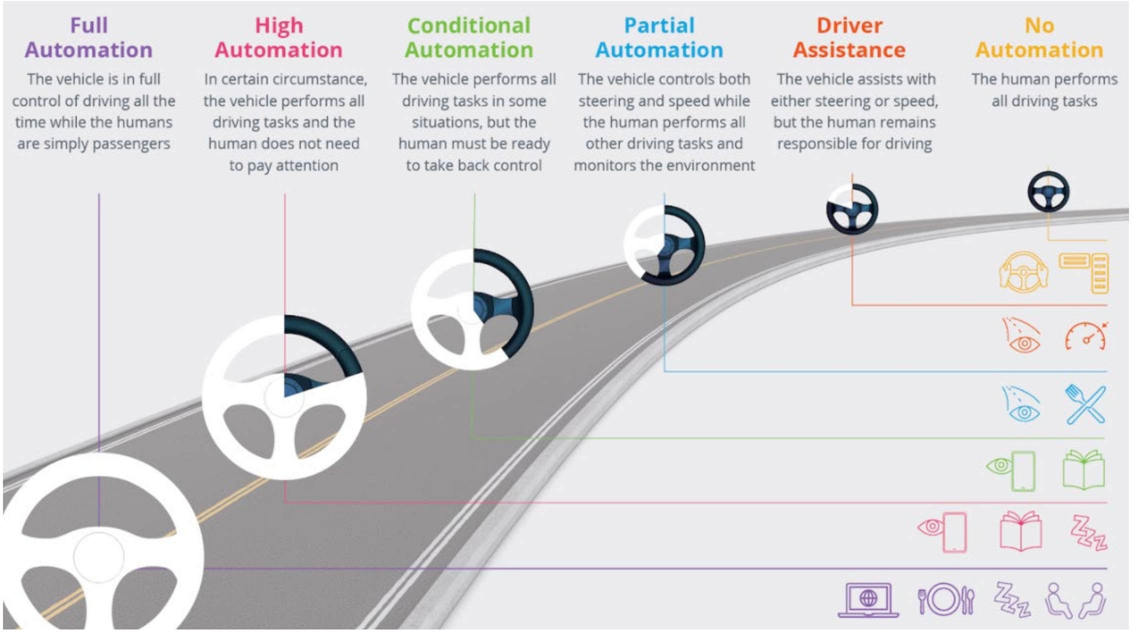


Fig. 63. Levels of the autonomous driving

Source:[30]

The ultimate level 5 will not require a driver at all, a vision that many are excited to embrace, once all the complex, inter- and intra-dependent technologies and infrastructure are established, tested and well proven.

5.4. Innovative transformation of the transport system: vector of logistics

At all times, important issues of logistics have been the speed of transportation and the rational use of transport infrastructure.

When we talk about the speed of transportation, we immediately mention air transport. However, the issue of increasing the speed of air transportation is not raised, as it leads to a decrease in economic efficiency. In the field of air transport, much attention is paid to satellite-based air traffic control systems.

*Satellite-based air traffic control systems.*Air traffic control systems in operation today are ground-based, using technology that that dates back to the 1960's. Satellite-based control systems allow air traffic controllers to be more efficient. The U.S. is currently working on NextGen, a satellite-based air traffic control system that is being implemented in stages through 2025. GPS technology will be used to increase accuracy and shorten routes.

NextGen is expected to save time and fuel, reduce air traffic delays, increase flight capacity and permit air traffic controllers to monitor aircraft with improved safety margins. Once NextGen is rolled out across America's airports, airplanes will be able to fly closer together, making it easier to take direct routes and avoid delays caused by “stacking” planes waiting for take-off. NextGen will reduce aircraft gridlock, both in the sky and in airports [33]. Instead, a great potential to increase the speed of transportation is seen in rail transport.

*Maglev trains.*Maglev (short for “magnetic levitation”) trains hover about 4 inches above their tracks and are propelled by electrically-charged magnets (Fig. 64). Riders claim the trains are exceptionally comfortable and stable. Maglev trains have been recorded to travel at a rate of 375 miles per hour (mph).

Maglev trains are already in operation in China and Germany and are expected to become a common mode of transportation throughout the world by 2030 [33].

*Hyperloop transportation systems.*This transportation concept, conceived by Elon Musk, founder of Tesla Motors and SpaceX, is currently being designed and developed. Hyperloops are essentially transportation tubes that run pods of passengers or freight through a pressurized track at high speeds (Fig. 65). Hyperloops run at an average of 600 mph; their top speed is 760 mph. There are several companies currently working to advance the technology [33].

Hyperloop Transportation Technologies (HyperloopTT) has released details of their plan to create the world’s first commercial Hyperloop system in Abu Dhabi. Situated on the border between Abu Dhabi and Dubai, in close proximity to both the Al Maktoum International Airport and World Expo 2020 site, the HyperloopTT will begin with the construction of six miles (ten kilometers) of infrastructure, with future development potentially creating a commercial Hyperloop network across the United Arab Emirates and beyond [42].

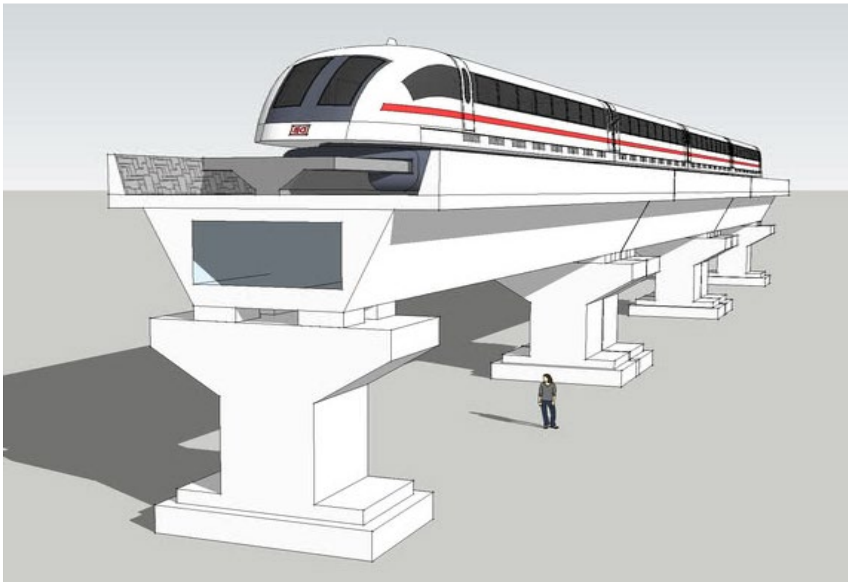


Fig. 64. **Maglev’s model**

Source: [43]

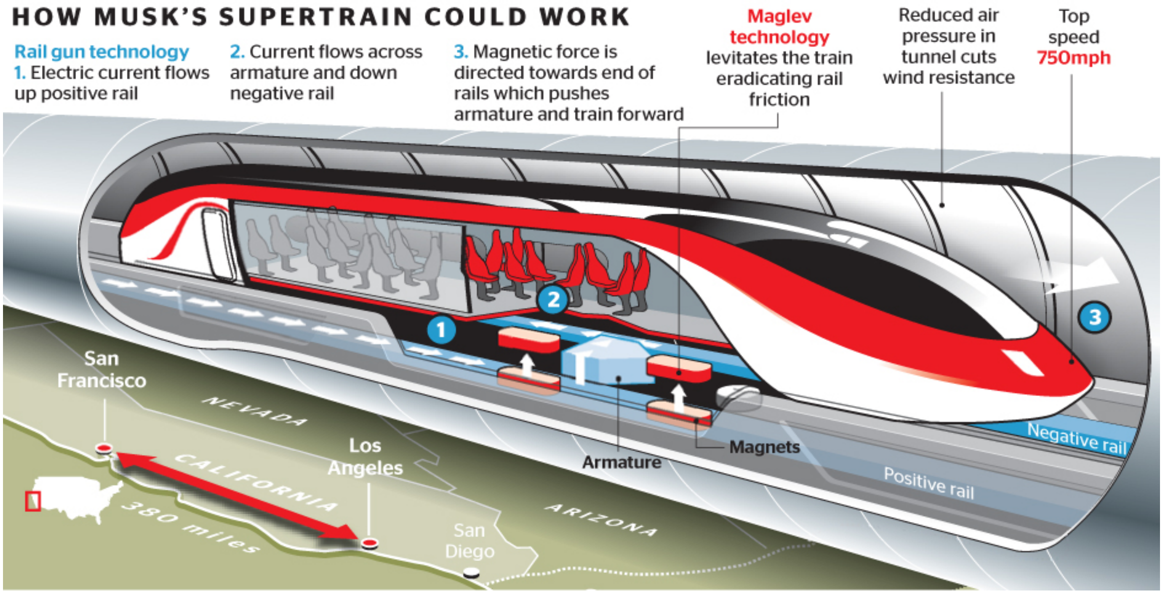


Fig. 65. **Hyperloop's model**

Source: [44]

Not only Maglev and Hyperloop hover above the ground, but also buses.

*Elevated buses.*China is working on a bus system that will reduce traffic congestion. The elevated bus is a vehicle that "straddles" traffic. It runs on a special track that allows regular vehicles to drive underneath (Fig. 66). The Transit Elevated Bus (TEB) system is currently being designed in China and is expected to reduce traffic congestion by 30 percent [33].

Fig. 66. **Elevated bus model**

Source: [45]

The efficiency of transport infrastructure management is promoted by the suppliers of special software products and services.

App-based access to all forms of transportation. A Finnish-based startup created an app that coordinates all forms of city transportation into a single platform, potentially providing a single solution for all transportation needs.

The Whim app eliminates the need for different passes and tickets. Instead of juggling each service's payment service, users opt for different subscriptions.The goal is to simplify travel [34].

Cars-as-a-Service. Cars-as-a-Service or CaaS alludes to a forthcoming car rental administration that enables city drivers to take part in a ride-sharing facility. Smart gadget owners can signal an auto with driverless innovation through an application, which lifts them up for their delivery or transportation needs. The considerable thing about the innovation is that no driver's permit is required to get to one of these vehicles, working as a driverless Uber. This means of transport will be noticeably unique in numerous urban areas around the world, particularly where vehicular pollution and traffic are heating issues [39].

Bicycle share programs. Bicycle share programs allow riders to pay a small fee to ride a bike from one point to another, leaving the bike at the ride share station. This is a helpful program in urban areas where traffic can make it easier – and faster – to ride a bike than drive a car. Bicycles are good for the environment as they do not emit harmful emissions; bikes are an eco-friendly mode of transportation as well as giving riders the opportunity to get healthy exercise. Bicycle share programs are already in operation in several major metropolitan areas, and are expected to be become more common in the future [33].

App lets users rent out empty parking spaces. Kazakhstan startup TuraQshare, with support from Nazarbayev University, developed an app that allows users to register and rent out their empty parking spaces. The concept was created in July 2018 for the Astana Innovations Challenge, a startup competition aimed at incentivizing young developers to solve urban technological problems in Nur-Sultan, the capital of Kazakhstan. TuraQshare's founders, Nazarbayev University students AskhatSharipov and AnuarBaitulakov, came up with the idea to help manage traffic congestion. The aim of the app is to make it simple to promote parking spots across the city. In addition, TuraQshare provides a platform for people to earn money by renting their empty parking spots while they are away from home [34].

The future will bring dramatic technological improvements to the transportation sector, many of which are in unchartered terrain. The government may need to get involved and cooperate more closely with private investors, innovators and other stakeholders as an agent of public interest. Transportation has a rich history of both technical and policy innovation, a history that is likely to persist. Transportation is in an upheaval as it struggles to continue to support the prosperity and quality of life of our nation and others on the planet.

Whatever the future of transportation holds, it is clear that it will continue to play an intrinsic role in human history, making the world a safer and more interconnected place.

REFERENCES

1. V. Mochernyi V. (2002). Ekonomichna entsyklopediia: u 3-kh t. [Economic encyclopedia]. K.: Akademiia, 3. 952 p.

2. Laktionova O.E. (2002). Formirovanie logisticheskikh sistem: metodologiya i praktika [Formation of logistics systems: methodology and practice]*: monograph*. Donetsk: NAN Ukrainy. Institut ekonomiki promyshlennosti. 319 p.

3. Doroshkevych D.V. (2014). Stratehichne upravlinnia investytsiinym protsesom u rehionalnykh transportno-lohistychnykh systemakh: problemy teorii i praktyky [Strategic management of the investment process in regional transport and logistics systems: problems of theory and practice]*: monograph*. Kherson: Hrin D.S. 319 p.

4. Beketov Yu. A., Misyura N. I. (2005). Problemy strategicheskogo razvitiya transportnykh predpriyatiy v usloviyakh perekhodnoy ekonomiki [Problems of strategic development of transport enterprises in a transitional economy]. *Bulletin KhNADU, 29*. URL: http://cyberleninka.ru/article/n/problemy-strategicheskogo-razvitiya-transportnyh-predpriyatiy-v-usloviyah=perehodnoy-ekonomiki.

5. Zablodska I.V., Akhromkin Ye.M. (2013). Infrastrukturne zabezpechennia aktyvizatsii mizhrehionalnoho spivrobitnytstva v Ukraini: stan ta zadumy [Infrastructural support of intensification of interregional cooperation in Ukraine: state and plans.]. *Prometheus*, *1 (40)*, 22–36.

6. Tkachenko N. Yu. (2006). Transportna infrastruktura: sutnist, funktsii ta rol u zabezpechenni ekonomichnykh protsesiv [Transport infrastructure: essence, functions and role in ensuring economic processes]. *Bulletin of DonDUET. Series: "Economic Sciences"*, *4*, 56–61.

7. Government portal. The only web portal of the executive authorities of Ukraine: website. URL: http://www.kmu.gov.ua/control/annboxnews?box_id=244277705.

8. Bardi E., Coyle J., Novack R. (2006). Management of transportation. Thomson South-Western. 528 p.

9. Infrastructure productivity: How to save $1 trillion a year. Mckinsey.com: website. URL: https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insigh ts/infrastructure-productivity.

10. Dmytriieva O.I. (2020). Transportna infrastruktura yak obiekt derzhavnoho rehuliuvannia [Transport infrastructure as an object of state regulation]. *Problems and prospects of entrepreneurship development*, *1 (24)*, 52–63.

11. Dmytriieva O. I. (2020). Perspektyvy innovatsiinoho rozvytku transportnoi infrastruktury [Prospects for innovative development of transport infrastructure]. *International scientific journal "Internauka". Series: Economic Sciences*, *3 (35)*, 13–22.

12. Tiulkina K.O., Kumanov V.M. (2020). Problemy ta perspektyvy rozvytku transportnoi infrastruktury: dosvid zarubizhnykh krain ta Ukrainy [Problems and prospects of transport infrastructure development: experience of foreign countries and Ukraine]. URL: https://www.ukrlogos.in.ua/10.11232-2663-4139.05.10.html.

13. In search of a balance between infrastructure investment and debt sustainability: an information note for the CAREC High-Level Forum. Kazakhstan. 2019. 14 p.

14. Innovation center. Sino-Belarusian Industrial Park "Great Stone": website. URL: https://industrialpark.by/innovacionnij-centr.html

15. Leading markets and innovations. Facts about Germany: website. URL: https://www.tatsachen-ueber-deutschland.de/uk/kategoriyi/ekonomika-y-innovaciyi/providni-rynky-ta-innovaciyi.

16. Nazarov O.O. (2018). Problemy y perspektyvy rozvytku vysokoshvydkisnoho pasazhyrskoho zaliznychnoho transport [Problems and prospects of development of high-speed passenger railway transport]. *Collection of scientific works of DNUZT named after acad. V. Lazaryan*, *16*, 77–82.

17. Stasiuk O. M., Chmyrova L. Yu., Fediai N. O. (2020). Shvydkist yak konkurentna perevaha vysokoshvydkisnykh nazemnykh perevezen [Speed as a competitive advantage of high-speed ground transportation]. *Efficient economy, 2.* URL: http://www.economy.nayka.com.ua/pdf/2_2020/75.pdf.

18. Integration of ETCS and centralization system in SmartRail 4.0. Railways of the world: website. 2018. Vol. 12. URL: http://www.zdmira.com /arhiv/2018/zdm-2018-no-12#TOC

19. Top 7 trends in the transport industry. Stfalcon.com: website. URL: https://stfalcon.com/ru/blog/post/transportation-industry-trends.

20. Vysochinskaya O. (2018). 5 zabot gruzoperevozchikov, i kak tekhnologii s nimi spravlyayutsya [5 concerns of freight carriers, and how technology is coping with them]. Stfalcon.com: website. URL: https://stfalcon.com /blog/post/digitization-of-freight-transportation.

21. 3D printing of automotive components. Ultimaker-ukraine.com: website. URL: https://ultimaker-ukraine.com/tucci.

22. Volostnov A. (2018). Kakimi budut vozdushnye gavani budushchego? [What will the air harbors of the future be like?]. DX.media: website. URL: https://dx.media/articles/direct-speech/tsifrovaya-transformatsiya-aeroportov-kakimi-budut-vozdushnye-gavani-budushchego/

23. Airport technology trends. Tadviser.ru: website. URL: https://www.tadviser.ru/index.php%8B_%D0%B2_%D0%B0%D1%8D%D1%80%D0%BE%D0%BF%D0%BE%D1%80%D1%82.

24. Digital technologies at airports. Addreality.com: website. URL: https://addreality.com/ru/cifrovye-tehnologii-v-aeroportah.

25. Sales of electric cars in the world have almost doubled: the leader of the Tesla Model 3. The first electronic car "Autogeek": website. URL: https://autogeek.com.ua/prodazhi-elektromobiliv-v-sviti-zrosly-majzhe-vdvichi-lider-tesla-model-3/.

26. Hroma Ya.V., Hlushchenko Ya.I. (2019). Porivnialnyi analiz rynku avtomobiliv v Ukraini ta sviti [Comparative analysis of the car market in Ukraine and the world]. *Economic Bulletin of NTUU "KPI",* 16, 42–49.

27. Negrey V.Ya., Maslovskaya M.A. (2018). Tselesoobraznost' elektrifikatsii uchastkov zheleznoy dorogi [Feasibility of electrification of railway sections]. *Bulletin of Transport Economics and Industry*, *62*, 96–104.

28. About the Basic principles (strategy) of the state ecological policy of Ukraine for the period till 2030: Law of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/2697-19#n8

29. What is green transportation? URL: https://www.conserve-energy-future.com/modes-and-benefits-of-green-transportation.php

30. Automotive: innovations, trends and the intersection with semiconductors. URL: https://www.kla-tencor.com/advance/innovation/automotive-innovations-trends-and-the-intersection-with-semiconductors

31. Top 10 latest car technology innovations of the past decade. URL: https://www.cars24.com/blog/latest-car-technology-innovations

32. Olli Bus Local Motors. URL: https://free3d.com/3d-model/olli-bus-local-motors-591.html

33. Top 10 future transportation innovations. URL: https://www.marshmma.com/blog/top-10-future-transportation-innovations

34. Top 7 mobility and transport innovations from 2019. URL: https://www.springwise.com/innovation-snapshot/top-7-mobility-transport-2019

35. In Beijing, plastic bottles can pay for your subway ticket. URL: https://www.thecivilengineer.org/news-center/latest-news/item/1599-in-beijing-plastic-bottles-can-pay-for-your-subway-ticket

36. Smart road technology: digital highways of the future. URL: https://vrioeurope.com/en/smart-road-technology-digital-highways-of-the-future

37. Road safety: safe vehicles, safe drivers, safe roads. URL: https://www.acea.auto/video/animated-video-road-safety-safe-vehicles-safe-drivers-safe-roads

38. Lane Keeping Assist. URL: https://mycardoeswhat.org/safety-features/lane-keeping-assist

39. Top 11 tech trends and solutions in the automobile industry. URL: https://www.newgenapps.com/blogs/tech-trends-solutions-in-automobile-industry

40. Biometric Seat Research. URL: https://www.pinterest.com/pin/347199452492456120

41. The smart car seat that tackles ROAD RAGE: Chair gives drivers a relaxing massage or a blast of air to focus their attention. URL: http://en.people.cn/n/2015/ 1008/c202936-8959032.html

42. Transit futures: new innovations moving transport forward. URL: https://www.archdaily.com/926523/transit-futures-new-innovations-moving-transport-forward

43. Maglev train in 2020. URL: https://3dwarehouse.sketchup.com/model/uc221fa87-3944-4c39-820e-04deb78b2e71/Maglev-train-in-2020?hl=ru

44. The Hyperloop: future of travel. URL: https://xedknowledge.com/Coverstory_Demo.aspx?id=g8gQXxkYQbroVNrDQ2MnGA%3D%3D

45. Elevated bus. URL: https://play.google.com/store/apps/details?id=com.was.transit.elevated.bus.simulator3d&hl=en_SG&gl=US

5.5. Green logistics as a modern paradigm of balanced sustainable development of the national transport and logistics system in Ukraine

Henryk Dzwigol
Habilitated Doctor in Economics, Professor,
Silesian University of Technology (Gliwice, Poland)
henryk.dzwigol@poczta.fm
https://orcid.org/0000-0002-2005-0078

Aleksy Kwilinski
Ph.D., Doctor in Economics, Professor,
The London Academy of Science and Business, London, United Kingdom
a.kwilinski@london-asb.co.uk
https://orcid.org/0000-0001-6318-4001

Nataliia Trushkina
PhD (in Economics), Senior Research Fellow of the Department
of Regulatory Policy and Entrepreneurship Development,
Institute of Industrial Economics of NAS of Ukraine (Kyiv, Ukraine)
nata_tru@ukr.net
https://orcid.org/0000-0002-6741-7738

Ensuring sustainable development of transport and logistics systems requires the introduction of organizational, managerial and environmental technologies adequate to transformational transformations, as well as innovative models to reduce the negative impact of transport on the environment. This is in line with the green growth concept proposed by the Organization for Economic Cooperation and Development. As international experience shows, improving the efficiency of the transport sector and organizing logistics activities can be achieved through the implementation of conceptually new management tools based on the principles of logistics, namely, systematic, process approaches, concepts of "lean" production, "just in time," sustainable development (Abazov 2021; Dalevska et al. 2019; Dyduch 2019; Dzwigol 2019; 2020a; 2020b; Dzwigol & Dźwigoł-Barosz 2018; 2020; Dzwigol et al. 2019a; 2019b; 2020a; 2020b; Kharazishvili et al. 2020; Lyulyov et al. 2021).

Today, leading scientists are conducting scientific discussions on the implementation of the concept of green growth in order to preserve the environment and improve the economic activities of enterprises. The desire of companies to create an ecological image with consumers has contributed to the development of a sustainable logistics concept (Boichuk & Kauf 2019) that includes green components and considers economic, social and environmental activities in the context of logistics management.

It is precisely the greening of logistics activities that is a key vector for business development, since most consumers consider priority those companies that carry out cargo transportation by "green" transport and use technologies that conserve natural resources. The use of "green" technologies in logistics has become as much a necessity as the implementation of a quality management system. As a consequence, according to “the Green Trends Survey” in the study “Towards Sustainable Logistics” (Christof & Ehrhart 2012), 59% of businesses found that green transportation of their products was recognized as a decisive factor in attracting consumers. Based on a survey by PE International (Great Britain) (McKinnon et al. 2010), the key advantages in the implementation of the green logistics concept are identified, which include the reduction of air emissions (33% of heads and top managers of companies); attracting new customers or developing new products (26% of respondents).

Thus, modern business conditions dictate new requirements for business development. The priority is green logistics as one of the most important components of the overall strategy of social responsibility of business in the context of the development of a circular economy. It should be noted that the role and importance of green logistics as a tool to support environmental safety is becoming more relevant every year, since it has become a socially useful and profitable symbiosis of ecology and economics as part of corporate environmental governance policies.

The term "green economy" was first mentioned in 1989 in a report by a group of leading economists to the government of the United Kingdom of Great Britain and Northern Ireland (Pearce et al. 1989). This concept entered wide circulation during the global economic crisis of 2008–2009. Thus, in 2009, the UN Environment Program published the report "Global Green New Deal", which considered the goals, objectives, elements, incentives and directions of domestic policy aimed at developing a green economy. The green economy has mainly been defined as a practical approach to achieve sustainable development.

Currently, the concept of a green economy is being actively discussed by scientists, experts, business and public organizations. UNEP experts (2011) formulate a green economy as an economy that leads to improved human well-being and social justice and at the same time significantly reduces environmental risks and ecological scarcity. According to this concept, the priorities of a green economy are, on the one hand, the maintenance and restoration of natural capital, the use of (Gureva 2019) renewable energy and low-carbon technologies for fossil fuels, an increase in the efficiency of resource and energy use, the formation of responsible behavior of urban residents, the transition to low-carbon mobility, and on the other – creating new jobs and increasing social justice.

In the last decade, a new concept of economic development, called the "circular economy", has received special attention among leading scientists. Proponents of this concept believe that circular growth will help to overcome the climate crisis and will contribute to the development of an inclusive green economy. The very definition of this kind of economy was formulated in their 2019 study by experts from the University of Oxford (Haney et al. 2019), based on a series of interviews conducted with participants in the Platform for Accelerating the Circular Economy (PACE). Most of the interviewed experts agreed that a circular economy is a regenerative type of economy in its design, aimed at preserving the greatest possible value of products, their components and materials, whose growth is not stimulated and does not depend on the exploitation of limited resources. At its core, this type of economy is viewed as a new trajectory for the development of society along the path of sustainability (Gureva 2019).

The evolutionary development of the circular economy took place in three main stages (Reike et al. 2018):

Stage I (1970-1990) – waste management – a number of environmental legislative measures were adopted in European countries and the United States. The concept of 3R (reduce, reuse and recycling) is becoming more and more interesting. A principle known as the polluter pays is emerging. The issue of waste management is central, but due to the underdeveloped environmental culture and thinking, an approach is gaining popularity in which the territory of less wealthy countries was used for waste disposal and/or recycling;

Stage II (1990-2010) – strategies for environmental efficiency – the idea of environmental payments (payment for pollution). Environmental problems were perceived by society as a kind of economic opportunity. In the early 2000s. a number of environmental problems have been recognized as global (ozone depletion, global warming). The scientific community is actively developing possible ways of waste-free production, but applicable only in industry;

Stage III (approximately 2010 – present) – maximum preservation in the era of resource depletion – the concept of a circular economy, having absorbed the ideas of theoretical research to the greatest extent, acquired its final form. The central problem is the posed threat to the survival of mankind in connection with the reduction and gradual disappearance of necessary natural resources, the growth of the world's population and the amount of waste. Companies are encouraged to develop taking into account three key principles: green innovation, alternative sources, and a change in the industrial paradigm. At the moment, about 500 companies in the world are using the circular economy strategy.

The transition from industrial to post-industrial society in the 60s. XX century, based on technological progress and an innovative development model, led to the appearance in the scientific literature of the concept of a circular economy. The concept of a circular economy was put forward in 1966 by the American economist Kenneth Ewart Boulding and had a pronounced ecological character: "... a person must find his place in a cyclical ecological system ...". Subsequently, the concept began to acquire a more economic character. (Boulding 1966; Boulding 1966a).

There are various scientific views on the origin of the "circular economy". As a rule, scientists identify it with the concepts of “cyclical economy”, “recovery economy”, “circular economy”, “green economy”, etc. A number of scholars believe that the circular economy is a new stage in the development of the concept of sustainable development and a green economy in particular. On the other hand, much less often, it is viewed as an independent direction in economic theory, which originated in the 1970s. XX century (Gureva 2019a; Esipova et al. 2018).

E. Mishenin and I. Koblyanskaya (2017) emphasize that the circular economy is not an analogue of the "green economy", but acts as a component of it, as a way to achieve sustainable development. M. Gureva (2019) proposes to group the approaches to the interpretation of the concept of "circular economy" over the period of its formation as follows: the global economic model (2004); activity (2007); new trend 4.0 (2013); economic model (2015); production system (2016); economic activity, tool (2017); philosophy, economics (2018).

Based on the foregoing, the existing scientific approaches to the definition of the term "circular economy" can be conventionally systematized into groups: closed loop economy, resource-based economy, alternative to traditional linear economics, use of production waste, economic activity, sustainable development strategy, green economy instrument, global economic model, recycling of secondary raw materials, closed-loop economic system based on R-principles, economic development concept, business philosophy.

Thus, a circular economy should be understood as an innovative approach to the organization of logistics processes based on the closed movement of resources with their minimum losses in the form of waste and the maximum involvement of secondary resources in production in order to achieve sustainable development of transport and logistics systems.

Analysis of the literature has shown that the overwhelming number of researchers (Su et al., 2013; Reike & Vermeulen, Witjes 2018; Kirchherr et al. 2018) use the particle "re", which characterizes the basic essence of the circular economy. The circular economy was originally based on three key principles called "3R": Reduce – Reuse – Recycle. But over time, they transformed into "9R": Rethink – Reduce – Reuse – Repair – Refurbish – Remanufacturing – Repurpose – Recycle – Recover.

A significant number of studies have been devoted to identifying factors that impede the development of a circular economy (Kirchherr et al. 2017; Pheifer 2017; Ritzén & Sandströ 2017). According to scientists (Kirchherr et al., 2018), the implementation of the circular economy concept in practice can be hampered by the following barriers:

cultural (ecological culture of companies, lack of interest and consumer awareness, work according to the principles of a linear economy, interest in the final value chain);

regulatory (limited closed procurement, lack of global consensus, prohibition of laws and regulations);

market-based (low quality materials, standardization, high investment value, limited funding for circular business models);

technological (ability to supply high quality remanufactured products, lack of scale for design demonstrations, lack of required exposure data).

N. Batova et al. (2019) have identified and systematized 5 groups of barriers to the development of a circular economy: socio-cultural, legal, information, technological and economic. Socio-cultural barriers hinder the development of a circular economy due to the existing differences in value attitudes and the level of environmental responsibility of society. Legal barriers are manifested in the form of restrictions imposed by current legislation. Insufficient awareness of consumers and producers about the essence and principles, best practices and best practices in the implementation of a circular economy creates information barriers. Economic barriers stem from a variety of factors, including the cost of circular innovation; lack of a clear methodology for assessing the economic efficiency of enterprises using secondary resources, effective mechanisms for financial support and preferences from the banking system and the public sector. and the state is also holding back the introduction of circular processes. It also has economies of scale that make waste collection and recycling less cost-effective for those who generate less waste.

Technological barriers to the introduction of a circular economy are characterized by the lack of a clear logistics infrastructure for the collection, extraction and processing of secondary resources; the lack of demonstration projects for working with new technologies, and as a result, concerns about the quality of products made from recycled materials and waste (Batova et al. 2019).

As the analysis shows, a circular economic investment strategy from a macroeconomic point of view could lead by 2030 to a 10% decrease in the cost of raw materials and a 7% increase in GDP in the European Union compared to the usual business model (Ellen Mac Arthur Foundation 2017). However, such a leap in development undoubtedly requires a development strategy focused on the specific potential of the economy, as well as appropriate infrastructure and administrative capacities (Müller & Wilts 2019).

In addition, it should be noted that the development of a circular economy contributes to obtaining a social effect through the creation of jobs. According to a study by the European Commission (2018), depending on how waste is handled, a different number of jobs can be created: for 10 thousand tons of used products, one job can be created during incineration, six jobs at disposal, 36 jobs – for recycling waste and up to 296 jobs for their recovery and reuse.

Reducing direct and indirect environmental costs is an important long-term opportunity for a circular economy. Direct costs are associated with waste management. However, the indirect costs of the use of natural resources, which are passed on to the general public, are also relevant. Globally, an international group of resource experts under the United Nations Environment Program estimates that these costs amount to up to 2.4 trillion dollars USA (Müller & Wilts 2019).

Studies by the European Environment Agency (2019) showed that the amount of financial resources mobilized by the public sector in the period 2013-2017. reached a total volume of 2 billion euros in various areas of the circular economy. In the coming years, this volume should be significantly increased. For example, during the same period, investments in climate protection reached almost 20 billion euros.

For example, Finland has experience in the effective implementation of circular economy solutions. The essence of the transition is to rethink value chains and build on new business models. Currently, there are several solutions developed by specialists from the Finnish Innovation Fund Sitra that are helping to accelerate the transition to a circular economy (Herlevi 2020). These include:

product-service systems and sharing models;

ways of value attitudes towards nutrition;

sustainable delivery models (efficient delivery models and logistics operations are critical for implementing circular economy solutions. RePack offers reusable packaging solutions that minimize the cost of air transport. Koepala offers foldable lunch boxes that are flat for storage and transport and that can be assembled into packaging products of various shapes, which turned the potential of the circular economy into real market results);

roadmaps for carbon neutral industries (important for the development of Finland's industry in the future; for example, a 300 million euro investment in a battery cluster, as well as the first multifunctional textile recycling center in Northern Europe, will treat 10% of textile waste; due to resource efficiency and recycling Betolar creates value by converting construction waste into concrete-like building materials with a carbon footprint of up to 90% less than conventional concrete);

circular economy education.

The BEROC Center for Economic Research, within the framework of the project “Building capacity for strategic planning and management of regional structural transformations in Belarus in the context of a circular economy”, conducted a survey of 452 enterprises from the Brest and Mogilev regions. The purpose of the survey was to identify the readiness of the business for circular transformation (Batova 2020).

As a result of the expert survey, it was found that the circular economy is important in terms of introducing innovations that will allow the production of new products and expand sales markets. At the same time, for a significant number of respondents, the concept of a circular economy is limited only to the processing of secondary raw materials and the use of production waste. That is, Belarusian enterprises do not understand that this concept is much broader. For example, they are not familiar with the green procurement tool, which involves taking environmental considerations into account when conducting tenders.

About 30% of respondents fear that the introduction of the principles of a circular economy will lead to increased costs and higher prices for the final product. Often a business does not understand that it is not necessary to immediately spend money on the implementation of a new model, it is enough to implement process innovations within small chains.

Among the main barriers to implementing a closed-loop business model, over 80% of respondents indicated insufficient financial resources. In second place is the lack of technologies suitable for enterprises, as well as the lack of information and case studies on the implementation of circular economy approaches. At the same time, about 40% of respondents indicated that the lack of a unified electronic database on the availability of waste and secondary material resources impedes a large-scale transition to a circular economy. It is in the field of waste management that most of the respondents see the main potential for transferring the enterprise's economy to a closed cycle. In general, 80% of enterprises, when developing long-term development strategies, focus primarily on increasing profits. They consider the introduction of the principles of a circular economy from the point of view of increasing economic efficiency.

The survey identified the prospects for the implementation of the principles of a circular economy in Belarus (Batova 2020). The first direction is ecodesign. This means that the product is initially designed to minimize environmental damage throughout its entire life cycle. The second is resource efficiency. It implies the organization of cleaner production and the maximum economy of materials, resources, raw materials. One of the results of the implementation is a reduction in financial costs and an increase in competitiveness. The third is the implementation of a circular business model, which consists of many elements, including green supply, the use of environmental innovation, and extension of the product life cycle. The sharing economy, which involves the sharing of assets and goods, is also a circular business model. This trend is the most developed in the world, it gives the maximum growth rates. And another circular business model is product as a service. This approach assumes that, for example, it is not a car that is bought, but the number of kilometers that need to be traveled, and the manufacturer deals with the service, technical support and disposal.

The fourth priority is industrial symbiosis, which allows businesses to reduce costs through increased collaboration. For example, a by-product of one of them can be a raw material for another. This allows you to compete by reducing the cost of raw materials.

According to H. Wiltz (2020), Head of the Circular Economy at the Wuppertal Institute for Climate, Environment and Energy, households in Belarus will save the most on transport (up to 80%), food (up to 40%) and construction from the introduction of circular economy principles (about 25%).

The concept of green logistics began to take shape in the world since the mid 80s of the 20th century. with the emergence of the concept of "social responsibility of business". It was revealed that the process of formation and development of the concept of green logistics was not easy. Thus, foreign scientists J.-P. Rodrigue, B. Slack, and C. Comtois (2001) define the content of the category "green logistics" broadly enough, without the subject and object of research. Within the framework of this concept, logistics activity is reduced only to a transport distribution system, which must be carried out on environmental principles. In addition, they argue that there are some inconsistencies between the concepts of “green” and “logistics”, as cost-saving strategies often conflict with environmental principles, which usually do not take into account environmental costs.

Researchers (Baumgarten 2004; Kümmetsteiner 2011; Christof & Ehrhart 2012) have shown that the origin, formation and further structuring of "green logistics" are closely intertwined with logistic principles. It has been established that a number of scientists have suggested calling the ecological direction of logistics "ecologically oriented logistics," "ecology" or "ecological logistics," which indicates the ecological orientation of logistics activities, as well as the creation of an integrated ecological system.

Analysis of literary sources indicates that over the past decades of the development of this scientific direction, scientists have not come to a common and unambiguous interpretation of the term "green logistics". Currently, there are many conceptual approaches to the consideration of the environmental component of logistics. This is due to a significant number of formed scientific schools, which have their own characteristics and approaches to the theoretical and applied aspects of the development of the concept of green logistics. However, all the proposed formulations of the terms "green logistics" and "environmental logistics" are usually generally accepted and have a broader meaning, without taking into account the specifics of the functioning of various spheres of economic activity, including transport and logistics.

It was established that in 2009 the countries of the Organization for Economic Cooperation and Development (OECD) adopted the Strategy for Environmentally Oriented ("Green") Growth as a tool for overcoming the financial and economic crisis for the medium (until 2030) and long-term (until 2050) prospects. South Korea has emerged as the green economy leader, announcing green growth as its national strategy. Following South Korea, China has taken a green economy course. And then the countries of the European Union began the transition to green development.

According to experts, the expected growth of the global market for green technologies is 6.9% (this is almost 2 times more than the growth rate of the world economy). According to forecasts, the total volume of this market by 2025 may increase to 5.9 trillion euros (BMU 2018).

If we analyze the data on the structure of the green technologies market, it can be noted that its two main segments are environmentally friendly production, accumulation and distribution of energy (21% and 20% in 2016 and 2020) and the energy efficiency submarket (26% and 25% in 2016 and 2020). Sustainable mobility and efficient use are projected to grow by 2025 raw materials and materials (BMU 2018).

If we consider the national transport and logistics system of Ukraine in a green economy, then it should be noted that its transformation is not being carried out efficiently enough. So, according to the Ministry of Finance of Ukraine, the share of budget expenditures on environmental protection (EPP) is insignificant and in 2019 amounted to only 0.7% of the total volume of state budget expenditures. This, in turn, is not in line with the Sustainable Development Goals 2016-2030. The share of total expenditures on environmental protection in the total GDP is insignificant and amounted to 4.2% in 2019 (State Statistics Service of Ukraine 2020; Environment of Ukraine 2019, pp. 195, 198).

The share of total expenditures on environmental protection in the field of transport and warehousing decreased in 2012-2019 by 4.3 percentage points, or from 6.2 to 1.9% of the total total expenditures on EP. During this period, there was a trend towards a reduction in the share of capital investments in the development of the transport and storage sector by 51 percentage points, or from 58.8 to 7.8% of the total

total expenditures on environmental protection in this area. The share of current expenditures on EP in the field of transport and warehousing, respectively, increased by 51 percentage points, or from 41.2 to 92.2% of the total total expenditures on environmental protection in this type of economic activity (State Statistics Service of Ukraine 2020; Environment of Ukraine 2019, pp. 191, 194, 198).

The share of current costs for OOPS in the field of transport and warehousing decreased in 2012-2019 by 1.2 percentage points, or from 3.7 to 2.7% of the total current expenditure on environmental protection. The share of expenses for the protection of atmospheric air and climate in the field of transport and storage facilities decreased by 1.6 percentage points, or from 2.4 to 0.8% of the total volume of these expenses for all types of economic activity. At the same time, the share of expenses for the protection of atmospheric air and climate in the field of transport and warehousing decreased by 3.1% in the total current expenditures for environmental protection in this area, or from 6.1 to 3% (State Statistics Service of Ukraine 2020; Environment of Ukraine 2019, pp. 172, 192, 198).

For 2012-2019 the share of capital investments in environmental protection in the field of transport and warehousing decreased by 10.9 percentage points, or from 11.3 to 0.4% of the total volume of capital investments in environmental protection for all types of economic activity (State Statistics Service of Ukraine 2020; Environment of Ukraine 2019, pp. 189, 191).

During the study period, the share of investments in equipment and installations related to environmentally friendly technologies in the field of transport and warehousing decreased by 18.2 percentage points, or 21.7 to 3.5% of the total volume of these investments. The share of investments in integrated technologies for the protection of atmospheric air and climate in the field of transport and storage facilities decreased by 22.8 percentage points, or 44.2 to 21.4% of the total volume of relevant investments. At the same time, the share of investments in integrated technologies for the protection of atmospheric air and climate in the field of transport and warehousing increased by 29.5 percentage points, or 60.9 to 90.4% of the total investment in equipment related to environmentally friendly technologies in this industry (State Statistics Service of Ukraine 2020; Activity of business entities 2019, p. 134).

For the period 2010-2019 the volume of emissions of pollutants into the air from mobile sources of pollution decreased by 35.2%. And their share in the total volume of emissions of pollutants increased by 1.9 percentage points. As the analysis shows, the total volume of air emissions from road transport decreased in 2010-2019 by 28.3%, or from 2313.8 to 1659.5 thousand tons. The volume of carbon dioxide emissions into the air from road transport increased by 13.4%, or from 1782.7 to 2021.1 thousand tons (State Statistics Service of Ukraine 2020; Environment of Ukraine 2019, pp. 26, 28).

Thus, the statistical analysis indicates the need to implement the principles and tools of green logistics as a modern paradigm for the sustainable development of the national transport and logistics system.

Based on the analysis of literary sources (Janbo & Songxian 2008; Brdulak & Michniewska 2009; Sbihi & Eglese 2009; Mesjasz-Lech 2011; Ubeda et al. 2011; Lai & Wong 2012; Dekker et al. 2012; Ćirović et al. 2014; Harris et al. 2014; Jedliński 2014; Seroka-Stolka 2014; Zhang et al. 2015), scientific views on the interpretation of the essence and content of the concept of "green logistics" are generalized. As a rule, scientists understand this term:

scientific direction and one of the factors of environmental preservation, based on resource-saving and environmentally friendly technologies;

a new direction, providing for the use of advanced logistics technologies and modern equipment in order to minimize pollution and increase the efficiency of using logistics resources;

from a theoretical and scientific-methodological point of view, the subordinate functionality of the "green" economy;

logistics based on resource-saving and environmentally friendly technologies;

a type of logistics in which scientific and practical activities take into account environmental aspects at all stages of movement of material and other flows corresponding to it in order to reduce destructive effects on the environment and optimize resource consumption;

innovative method in logistics;

within the framework of the concept of sustainable economic development, an effective approach to the management of resource and energy flows to reduce the environmental and economic damage to the environment and ensure effective innovative development of production;

a system of measures providing for the use of energy and resource-saving logistics technologies and modern equipment in all links of the supply chain in order to minimize the negative impact on the environment and increase the total consumer value of products;

an environmentally friendly and efficient transport distribution system;

scientific and practical activities aimed at optimizing and effective management of direct and reverse material and accompanying flows (information, financial, waste flows, harmful emissions, various natural resources and energy) in order to minimize the negative impact on the environment;

scientific and practical activity, which provides for the formation of an effective mechanism for integrating environmental and socio-economic aspects at all stages of planning, design and management of the supply chain of goods in order to minimize environmental and economic damage and increase the consumer value of products through the use of energy and resource-saving logistics technologies;

activities related to the eco-efficient management of the movement of logistics flows of products that move from the enterprise to the consumer, as well as return flows of goods in the "supplier-consumer" system;

a set of actions related to the assessment and minimization of the environmental consequences of logistics activities;

coordination of logistic activities of market entities with a focus on achieving economic and socio-ecological effect through the use of energy and resource saving technologies;

increasing environmental responsibility in the transport and logistics sector.

Based on the generalization of the terminological apparatus on the selected topic in accordance with various scientific concepts and as a result of the research (Zaloznova et al. 2018; Trushkina 2018; Koev et al. 2019; Koev et al. 2019a; Sandiuk et al. 2019; Kashchena et al. 2019; Trushkina 2019; Trushkina 2019a; Trushkina et al. 2020; Kwilinski et al. 2020; Trushkina 2020; Dźwigoł, Kwilinski, Trushkina, 2021; Dzwigol, Trushkina, Kwilinski, 2021) the author's approach to the formulation of the term "green logistics" is proposed. It is understood as a modern paradigm of balanced sustainable development of transport and logistics system; a circular economy instrument; mechanism for implementing the green economy; component of corporate social responsibility of business in the transport sector and logistics activities; type of economic activity, including the processes of material and technical supply, warehousing, environmentally friendly storage, production, customer service, transportation, sale of finished products, recycling (recycling and waste disposal), which allows to reduce the negative impact on the ecosystem and the environment in a circular economy.

For the effective implementation of the concept of green logistics, it is advisable to develop an organizational and economic mechanism, which is considered as a set of principles, tools, functions, methods and means aimed at reducing the level of greenhouse gas emissions and the costs of organizing logistics activities and various logistics services (transport, warehousing, marketing, etc.).

The components of the organizational and economic mechanism include resources; factors of influence; goals, principles, functions, methods, control levers; tools; information Technology; performance criteria. The key principles of the formation of the organizational and economic mechanism are recognized as consistency, integration, reliability, dynamism, compliance with the goals of sustainable development, efficiency.

In modern conditions of intensive development of the circular economy, the issues of environmental protection in the transport sector and in the organization of logistics activities are actualized. This should be done in the context of green growth and in line with the European TEN-T transport policy aimed at efficient use of resources and reducing greenhouse gas emissions.

It has been proven that green logistics is an effective tool for transforming transport and logistics systens. Based on the analysis and generalization of existing scientific approaches to the definition of the term "green logistics", it was established that a scientific direction is considered under it; the factor of preserving the environment with the help of environmentally friendly technologies; component of the green economy; type of logistics; economic activity; scientific and practical activities; type of activity related to the eco-efficient management of the movement of logistics product flows; a tool for ensuring the ecological safety of the ecosystem; a set of logistic approaches to optimizing waste and resource flows; environmentally friendly transport distribution system; coordination of logistics activities to achieve sustainable development.

At the same time, most scientists identify the concepts of "green" and "ecological logistics", which is understood as a scientific direction that involves the use of modern innovative logistics technologies; a set of actions aimed at minimizing the environmental consequences of logistics activities; integrated management of logistic processes (production, storage, waste transportation); a subsystem for managing product flows from supplier to consumer with minimal impact on the environment.

As a result of the study, it was proposed to consider the term "green logistics" from four scientific positions: as a concept of sustainable development of transport and logistics systens of different levels; circular economy tool; component of corporate social responsibility of business; type of walking activity.

The main principles of green logistics should be the application of an integrated approach to managing logistics flows; rational use of resources (production, financial, energy, information); minimal use of raw materials and packaging that are not recyclable; economically sound and environmentally friendly transportation and storage of material resources; maximum use of production waste, containers and packaging as secondary raw materials or their environmentally friendly disposal; optimization of costs for organizing logistics activities; minimization of risks in the operation of transport and transport and logistics systens; increasing the level of environmental education and personnel responsibility; introduction of innovative technologies to reduce the environmental burden on the environment; application of information systems and digital technologies in the field of environmental protection.

The implementation of the green logistics mechanism helps to minimize the costs of managing the movement of logistics flows while maintaining the required level of environmental safety, which is one of the important requirements for the implementation of the concept of corporate social responsibility of business in a circular and green economy.

REFERENCES

1. Abazov, R. (2021). Education for sustainable development and ICT: The case of MDP program at al-Farabi KazNU. *Herald of Journalism, 58*(4), 34-43. https://doi.org/10.26577/HJ.2020.v58.i4.04
2. Batova, N., Shershunovich, E., Tochickaja, I. (2019). Circular Economy in Belarus: barriers to transition. *BEROC Green Economy Policy Paper Series*, PP no. 9. http://www.beroc.by/upload/iblock/41c/41c28e417ff84b7b98895d34ab20c782.pdf (in Russian)
3. Batova, N., Sachek, P., Tochickaja, I. (2019). Financing circular business projects. *BEROC Green Economy Policy Paper Series*, PP no. 9. http://www.beroc.by/webroot/delivery/ files/PP_GE_6_finance.pdf (in Russian)

4. Batova, N. (2020). Circular transformation in Belarus is a small-step strategy. October 14. https://zautra.by/news/ekspert-tcirkuliarnaia-transformatciia-v-belarusi-eto-strategiia-malykh-shagov (in Russian)
5. Baumgarten, H. (2004). Supply Chain Steuerung und Services. Logistik Dienstleister managen globale Netzwerke. Best Practices. Berlin, Springer, Auflage.
6. BMU (2018). Schulze: GreenTech ist Modernisierungstreiber unserer Wirtschaft. April 13. https://www.bmu.de/pressemitteilung/schulze-greentech-ist-modernisierungstreiber-unserer-wirtschaft/.
7. Boichuk, N., Kauf, S. (2019). Sustainable logistics: a framework for green city logistics – examples of Polish cities. *Conference Proceedings of the 9th Carpathian Logistics Congress - CLC 2019*, December 2-4, 2019, Zakopane, Poland, 339-346.
8. Boulding, K. E (1966). Economic Analysis; Volume I Microeconomics (Hardcover). 4th ed. New York: Harper & Row.
9. Boulding, K. (1966a). The Economics of the Coming Spaceship Earth. In: Jarrett, H., Ed., *Environmental Quality in a Growing Economy, Resources for the Future. Johns Hopkins University Press, Baltimore*, 3-14.
10. Brdulak, H., Michniewska, K. (2009). Zielona logistyka, ekologistyka, zrownowa zony rozwoj w logistyce. Koncepcje i strategie logistyczne. *Logistyka*, 4, 8-15.
11. Christof, Dr., Ehrhart, E. (2012). Delivering Tomorrow: Towards Sustainable Logistics. Bonn, Germany: Deutsche Post AG.
12. Ćirović, G., Pamučar, D., Božanić, D. (2014). Green logistic vehicle routing problem: Routing light delivery vehicles in urban areas using a neuro-fuzzy model. *Expert Systems with Applications*, *41*(9), 4245-4258. https://doi.org/10.1016/j.eswa.2014.01.005
13. Dalevska, N., Khobta, V., Kwilinski, A., & Kravchenko, S. (2019). A Model for Estimating Social and Economic Indicators of Sustainable Development. *Entrepreneurship and Sustainability Issues, 6*(4), 1839-1860. https://doi.org/10.9770/jesi.2019.6.4(21)
14. Dekker, R., Bloemhof, J., Mallidis, I. (2012). Operations Research for Green Logistics – an overview of aspects, issues, contributions and challenges. *European Journal of Operational Research*, *219*(3), 671-679.
15. Dyduch, W. (2019). Organizational Design Supporting Innovativeness. *Przegląd Organizacji,* 6, 16-23. https://doi.org/10.33141/po.2019.06.02
16. Dzwigol, H. (2019). Research Methods and Techniques in New Management Trends: Research Results. *Virtual Economics, 2*(1), 31-48. https://doi.org/10.34021/ve.2019.02.01(2)
17. Dzwigol, H. (2020a). Innovation in Marketing Research: Quantitative and Qualitative Analysis. *Marketing and Management of Innovations,* 1, 128-135. http://doi.org/10.21272/mmi.2020.1-10

18. Dzwigol, H. (2020b). Methodological and Empirical Platform of Triangulation in Strategic Management. *Academy of Strategic Management Journal, 19*(4), 1-8.
19. Dzwigol, H., & Dźwigoł-Barosz, M. (2018). Scientific Research Methodology in Management Sciences. *Financial and Credit Activity: Problems of Theory and Practice, 2*(25), 424-437. https://doi.org/10.18371/fcaptp.v2i25.136508
20. Dzwigol, H., & Dzwigol-Barosz, M. (2020). Sustainable Development of the Company on the Basis of Expert Assessment of the Investment Strategy. *Academy of Strategic Management Journal, 19*(5), 1-7.
21. Dzwigol, H., Aleinikova, O., Umanska, Y., Shmygol, N., & Pushak, Y. (2019a). An Entrepreneurship Model for Assessing the Investment Attractiveness of Regions. *Journal of Entrepreneurship Education, 22*(1S), 1-7.
22. Dzwigoł, H., Dzwigoł–Barosz, M., Zhyvko, Z., Miskiewicz, R., & Pushak, H. (2019b). Evaluation of the Energy Security as a Component of National Security of the Country. *Journal of Security and Sustainability Issues, 8*(3), 307-317. http://doi.org/10.9770/jssi.2019.8.3(2)
23. Dzwigol, H., Dźwigoł–Barosz, M., & Kwilinski, A. (2020c). Formation of Global Competitive Enterprise Environment Based on Industry 4.0 Concept. *International Journal of Entrepreneurship, 24*(1), 1-5.
24. Dzwigol, H., Dzwigol-Barosz, M., Miskiewicz, R., & Kwilinski, A. (2020). Manager Competency Assessment Model in the Conditions of Industry 4.0. *Entrepreneurship and Sustainability Issues*, 7(4), 2630-2644. https://doi.org/10.9770/jesi.2020.7.4(5).
25. Dźwigoł, H., Kwilinski, A., Trushkina, N. (2021). Green Logistics as a Sustainable Development Concept of Logistics Systems in a Circular Economy. *Proceedings of the 37th International Business Information Management Association (IBIMA)*, 1-2 April 2021 (pp. 10862-10874). Cordoba, Spain: IBIMA Publishing.
26. Dzwigol, H., Trushkina, N., Kwilinski, A. (2021). The Organizational and Economic Mechanism of Implementing the Concept of Green Logistics. *Virtual Economics*, 4(2), 74-108. https://doi.org/10.34021/ve.2021.04.02(3).
27. Ellen MacArthur Foundation (2017). Achieving, Growth Within. A 320-Billion Circular Economy Investment Opportunity available to Europe up to 2025. Brüssel.
28. Esipova, O. V., Blazhnov, N. M., Satsyuk, I. A. (2018). Tsirkulyarnaya ekonomika [Circular economy]. *Modern science: current issues, achievements and innovations*, 107-110. (in Russian).
29. European Commission (2018). Impacts of circular economy policies on the labour market. Final Report and Annexes. Luxembourg.
30. European Environment Agency (2019). Paving the way for a circular economy. Insights on status and potentials. *EEA Report* No. 11/2019. Publications Office of the European Union. Luxemburg.

31. Gureva, M. A. (2019). Teoreticheskie osnovy kontsepta tsirkulyarnoy ekonomiki [The theoretical basis of the concept of circular economy]. *Journal of International Economic Affairs, 9*(3), 2311-2336. https://doi.org/10.18334/eo.9.3.40990 (in Russian)
32. Gureva, M .A. (2019). Teoreticheskie osnovy tsirkulyarnoy ekonomiki [The theoretical basis of circular economy]. *Culture and the environment – the basics of sustainable development of Russia. Green bridge through the generations*, 54-59. (in Russian)
33. Haney, A., Krestyaninova, O., Love, Ch. (2019). The Circular Economy Boundaries and Bridges. Oxford: Said Business School, University of Oxford. https://www.sbs.ox.ac.uk/sites/default/files/2019-09/the-circular-economy.pdf.
34. Harris, I., Mumford, C.L., Naim, M.M. (2014). A hybrid multi-objective approach to capacitated facility location with flexible store allocation for green logistics modeling. *Transportation Research Part E. Logistics and Transportation Review*, 66, 1-22. https://doi.org/10.1016/j.tre.2014.01.010
35. Janbo, L., Songxian, L. (2008). The Form of Ecological Logistics and Its Relationship Under the Globalization. *Ecological Economy*, 4, 290-298.
36. Jedliński, M. (2014). The Position of Green Logistics in Sustainable Development of a Smart Green City. *Procedia – Social and Behavioral Sciences*, 151, 102-111. https://doi.org/10.1016/j.sbspro.2014.10.011
37. Jiao, W., Boons, F. (2014). Toward a research agenda for policy intervention and facilitation to enhance industrial symbiosis based on a comprehensive literature review. *Journal of Cleaner Production*, *67*(15), 14-25. https://doi.org/10.1016/j.jclepro.2013.12.050
38. Kashchena, N., Solokha, D., Trushkina, N., Potemkin, L., Mirkurbanova, R. (2019). Use of multi-agent simulation modeling for predicting the sales of wholesale trade companies. *Journal of Management Information and Decision Sciences*, *22*(4), 483-488.
39. Kharazishvili, Y., Kwilinski, A., Grishnova, O., Dzwigol, H. (2020). Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with Calculations Based on the Case Study of Ukraine). *Sustainability*, *12*(21), 8953. https://doi.org/10.3390/su12218953.
40. Kirchherr, J., Hekkert, M. Bour, R., Huibrechtse-Truijens, A., Kostense-Smit, E., Muller, J. (2017). Breaking the Barriers to the Circular Economy. Deloitte.
41. Kirchherr, J., et al. (2018). Barriers to the circular economy: evidence from the European Union (EU). *Ecological Economics*, 150, 264-272. https://doi.org/10.1016/j.ecolecon.2018.04.028
42. Koev, S.R., Tryfonova, O., Inzhyievska, L., Trushkina, N., Radieva, M. (2019). Management of Domestic Marketing of Service Enterprises. *IBIMA Business Review*, 2019, Article 681709. https://doi.org/ 10.5171/2019.681709
43. Koev, S.R., Tryfonova, O., Inzhyievska, L., Trushkina, N., Radieva, M. (2019a). Contact personnel assessment as a prerequisite for introduction of internal marketing system. *Proceedings of the 33rd International Business*

Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision 2020, 6497-6510.
44. Kümmetsteiner, G. (2011). Handbuch ‘Ökologistik. Hochschule Amberg-Weiden.
45. Kwilinski, A., Zaloznova, Yu., Trushkina, N., Rynkevych, N. (2020). Organizational and methodological support for Ukrainian coal enterprises marketing activity improvement. *E3S Web of Conferences*, 168, Article 00031. https://doi.org/10/1051/e3sconf/202016800031
46. Lai, K., Wong, C.W. (2012). Green logistics management and performance: Some empirical evidence from Chinese manufacturing exporters. *Omega*, *40*(3), 267-282. https://doi.org/10.1016/j.omega.2012.07.002
47. Lyulyov, O., Pimonenko, T., Kwilinski, A., Dzwigol, H., Dzwigol-Barosz, M., Pavlyk, V., & Barosz, P. (2021). The Impact of the Government Policy on the Energy Efficient Gap: The Evidence from Ukraine. *Energies,* 14(2), 373. https://doi.org/10.3390/en14020373
48. McKinnon, A., Browne, M., Whiteing, A., Piecyk, A. (2010). Green Logistics. Improving the Environmental Sustainability of Logistics. 3nd ed. London: Published by Kogan Page.
49. Mesjasz-Lech, A. (2011). Efektywnosc okonomiczna i sprawnosc ekologiczna logistyki zwrotnei. Czestochowa: Published by Technical University of Czestochowa, 43-46.
50. Mishenin, E., Koblyanskaya, I. (2017). Perspektivy i mekhanizmy razvitiya «Tsirkulyarnoy» ekonomiki v globalnoy srede’ [Prospects and mechanisms of development of Circular economy in a global environment]. *Marketing i menedzhment innovatsiy*, 2, 329-343. (in Russian)
51. Müller, A., Wilts, H. (2019). Bestandsaufnahme für die erfolgreiche Planung und Umsetzung einer Kreislaufwirtschaft in Belarus. Eine Analyse von Stärken und Schwächen sowie von Chancen und Risiken im Gebiet Brest’ Angefertigt vom Wuppertal Institut im Auftrag der Deutschen Gesellschaft für Internationale Zusammenarbeit (GIZ). Berlin.
52. Pearce, D., Markandya, A., Barbier, E. (1989). Blueprint for a Green economy’. London: Earthscan Publications Ltd.
53. Pheifer, A. G. (2017). Barriers and Enablers to Circular Business Models. Brielle.
54. Reike, D., Vermeulen, W.J.V., Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? – Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, 135, 246-264. https://doi.org/10.1016/j.
resconrec.2017.08.027
55. Ritzén, S., Sandström, G. Ö. (2017). Barriers to the Circular Economy – integration of perspectives and domains. *Procedia CIRP*, 64, 7-12.

56. Rodrigue, J.-P., Slack, B., Comtois, C. (2001). Green Logistics (the Paradoxes of). *The Handbook of Logistics and Supply Chain Management* (pp. 339-350). London, Pergamon.
57. Sandiuk, H., Lushpiienko, Yu., Trushkina, N., Tkachenko, I., Kurganskaya, E. (2019). Special Procedures for Electronic Public Procurement. *Journal of Legal, Ethical and Regulatory Issues*, 22. Special Issue 2. Business laws and legal rights: research and practice. URL: https://www.abacademies.org/articles/special-procedures-for-electronic-public-procurement-1544-0044-22-SI-2-351.pdf
58. Sbihi, A., Eglese, R.W. (2009). Combinatorial optimization and Green Logistics. *Annals of Operations Research, 175*(1), 159-175. https://doi.org/10.1007/s10479-009-0651-z
59. Seroka-Stolka, O. (2014). The Development of Green Logistics for Implementation Sustainable Development Strategy in Companies. *Procedia – Social and Behavioral Sciences*, 151, 302-309. https://doi.org/10.1016/j.sbspro.2014.10.028
60. State Statistics Service of Ukraine (2020). Activity of business entities 2019: statistical yearbook. Kyiv.
61. State Statistics Service of Ukraine (2020). Environment of Ukraine 2019: statistical yearbook. Kyiv.
62. Su, B., Heshmati, A., Geng, Y., Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *J. Clean.* Prod., 42, 215-227.
63. Trushkina, N. (2018). Green logistics as a tool to improve the quality of life in conditions of globalization. *Contemporary Problems of Improve Living Standards in a Globalized World*: Volume of Scientific Papers (pp. 147-152). Opole, Publishing House WSZiA.
64. Trushkina, N. (2019). Development of the information economy under the conditions of global economic transformations: features, factors and prospects. *Virtual Economics*, 2(4), 7-25. https://doi.org/10.34021/ve.2019.02.04(1)
65. Trushkina, N. V. (2019a). Green logistics as a component of corporate social responsibility of business. *III International Scientific Conference The Modern Trends in the Development of Business-Social Responsibility*: Conference Proceedings, June 28th, 2019, Nova School of Business and Economics, Lisbon, Portugal (pp. 112-115). Riga: Baltija Publishing (in Russian).
66. Trushkina, N., Abazov, R., Rynkevych, N., Bakhautdinova, G. (2020). Digital Transformation Organizational Culture under Conditions of the Information Economy. *Virtual Economics*, 3(1), 7-38. https://doi.org/10.34021/ve.2020.03.01(1)
67. Trushkina, N. (2020). International experience in implementing the mechanism of “green” financing for sustainable development of transport and logistics systems. *Competitiveness and sustainable development*: Book of abstracts of the 2nd Economic International Conference (pp. 10), Chisinau, Republic of Moldova, November 20th, 2020. Chişinău: Tehnica-UTM.

68. Ubeda, S., Arcelus, F., Faulin, J. (2011). Green logistics at Eroski: A case study. *International Journal of Production Economics*, *131*(1), 44-51. https://doi.org/10.1016/j.ijpe.2011.04.041
69. UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – A Synthesis for Policy Makers. https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf.
70. Zaloznova, Yu., Kwilinski, A., Trushkina, N. (2018). Reverse logistics in a system of the circular economy: theoretical aspect. *Economic Herald of the Donbas, 4*(54), 29-37.
71. Zhang, S., Lee, C., Chan, H., et al. (2015). Swarm intelligence applied in green logistics: A literature review. *Engineering Applications of Artificial Intelligence*, 37, 154-169. https://doi.org10.1016/j.engappai.2014.09.007

5.6. Green investments as a tool for financial support of the regional transport and logistics system

Nataliia Trushkina
PhD (in Economics), Senior Research Fellow of the Department of Regulatory Policy and Entrepreneurship Development, Institute of Industrial Economics of NAS of Ukraine (Kyiv, Ukraine)
nata_tru@ukr.net
https://orcid.org/0000-0002-6741-7738

Olena Krylova
PhD (Engineering), Associate Professor, Associate Professor of the Department of Economic Analysis and Finance, National Technical University "Dnipro Polytechnic" (Dnipro, Ukraine)
Krylo-ov@i.ua
https://orcid.org/0000-0002-4210-5068

Olena Serhieieva
PhD (in Public Administration), Assistant Professor, Assistant Professor of the Department of International Trade, Alfred Nobel University (Dnipro, Ukraine)
sergeyeva.1966@gmail.com
https://orcid.org/0000-0003-4346-5425

The change of the modern paradigm of thinking leads to the reorganization of logistics processes and the need to transform the regional transport and logistics systems of economic regions of Ukraine in the context of the concepts of green economy. A survey conducted in 2019 by the consulting company PwC found that 41% of managers of transport and logistics companies in 85 countries are concerned about climate change and environmental damage associated with the growth prospects of their business.

The World Economic Forum has established that greenhouse gas emissions from logistics account for 5.5% of global greenhouse gas emissions. According to UN estimates, the global transport sector generates 25% of total greenhouse gas emissions. Annually, the total loss from the negative effects of the transport industry is 7-10% of GDP. The damage to health caused by environmental pollution from mobile sources is 1 trillion dollars USA per year. According to official Eurostat data, air pollution from road transport causes more than 400 thousand premature deaths each year.

Therefore, large-scale investment programs are being actively implemented in the world to modernize transport and infrastructure by "greening" them in order to minimize the negative impact on the environment and maintain a competitive position. Such programs are usually based on the technologies of the third and fourth industrial revolutions. Significant advantages of the third industrial revolution include the "greening" of transport systems through the transition to hydrogen and electric transport, which contributes to a dramatic improvement in the quality of the environment. For example, the EU Transport Strategy envisages a reduction in greenhouse gas emissions by approximately 20% from their level in 2008, and in general by 2050 – by 80-95% below the level of 1990.

According to the National Transport Strategy of Ukraine for the period up to 2030, it is necessary to take into account such a global trend of transport development as the use of "green" modes of transport, priority of environmental protection needs and preservation of valuable protected areas during transport infrastructure development. The strategy plans to reduce greenhouse gas emissions from mobile sources to 60% of 1990 levels.

Given this, it is advisable to search for innovative tools and scientifically sound "green" solutions, non-traditional sources of funding, as well as the introduction of fundamentally new organizational and management approaches and "green" technologies to improve the efficiency of regional transport and logistics systems in Ukraine. In the scientific literature there are many approaches to the consideration of the environmental component of logistics (Z. Jianwei, Z. Minjie, Z. Liwei, 2011; S. Pulawska, W. Starowicz, 2014; L. Simão, M. Gonçalves, C. M. T. Rodriguez, 2016; M. Moroz, Z. Polkowski, 2016; I. Urbanyi-Popiołeka, 2019; W. Liu et al., 2020). The greening of logistics is recognized as a key driver of business development, as most consumers prioritize those companies that carry out freight transportation by "green" transport and use technologies that conserve natural resources.

Based on the analysis conducted by the consulting company PwC, it is established that the emphasis on environmental sustainability and stringency of emission standards will force transport and logistics companies to move to environmentally friendly and safe decisions, ie to "green" logistics. Climate change is expected to continue to affect meteorological phenomena, leading to destabilization of supply chains. The reduction of stocks of natural resources will lead to higher prices for them and will promote the processing and more efficient allocation of resources. As a result, sustainable and environmental development issues will be in high demand in the long run.

A public opinion poll commissioned by the e-commerce delivery platform Sendcloud found that the majority of British consumers support the introduction of "green" technologies in manufacturing and logistics. According to 57% of respondents, the growth of online shopping through online shopping will lead to greater environmental pollution. At the same time, 38% of respondents are willing to pay extra for the delivery of goods on environmentally friendly transport. It should be emphasized that the COVID-19 pandemic has also forced consumers to reconsider their attitudes towards sustainable development and to consider the impact of purchases on the environment, society and business (Environmental, Social, and Corporate Governance, ESG).

According to a survey conducted by the Internet provider Orange Business Services, which surveyed 320 managers of international companies, including in the field of transport and logistics, 85% of respondents are willing to invest in business sustainability. And 59% of respondents said they could not allow the use of unethical and non-environmental technologies, as this would affect the level of profitability of companies. An express survey of 8738 consumers from 22 countries conducted by PwC in 2021 as part of the Global Consumer Behavior Survey found that 55% of respondents buy products from companies with a clear environmental policy, and 54% prefer goods in ecological packing. Despite a wide range of scientific developments on selected topics, methodological issues of "green" financing of infrastructure projects in the field of transport and logistics remain unresolved and require further research. And this problem acquires special significance in the current conditions of green transformation of regional transport and logistics systems in the context of the European Green Deal. Consider this on the example of the Black Sea region.

As the analysis shows, the share of current expenditures on environmental protection in the field of transport and warehousing in the economic region in 2020 was 6.7% of the total Ukrainian expenditures (in 2017 – 5.8%). At the same time, the share of current expenditures on environmental protection in the field of transport and warehousing in the Kherson region increased by 2.3 percentage points or from 0.7 to 3% of total current expenditures in the area, and in Mykolayiv – by 1.1 p.p. or from 3.2 to 4.3%. At the same time, there is a reduction in the share of these costs in the Odessa region by 3.4 percentage points (from 96.1 to 92.7%) (*Table 30*).

In addition, the share of capital investment in environmental protection in the field of transport and warehousing in the economic region decreased annually and in 2020 amounted to 11.1% of the total volume of capital investment in this area (in 2017 – 24.2 %). Investment in environmental protection in the field of transport and warehousing took place in 2017 only in Odessa region (100% of the total regional capital investment by this type), in 2020 – in Mykolaiv (30.5%) and Odessa (69.5%) areas. In the Kherson region during this period there was no funding for transport and warehousing in the direction of environmental protection.

Table 30

Current expenditures and capital investments for environmental protection in the field of transport and warehousing in the Black Sea region, *thousand UAH (at actual prices)*

Indicators / Regions	Years			
	2017	2018	2019	2020
Current Expenses				
Black Sea region	29882,5	41575,1	37901,1	48297,5
including areas: Mykolayiv	957,8	2278,7	603,8	2067,1
Odessa	28730,1	37250,3	35124,2	44763,7
Kherson	194,6	2046,1	2173,1	1466,7
Capital Investments				
Black Sea region	15811,5	13405,4	19787,7	10060,7
including areas: Mykolayiv	–	9,6	635,5	3065,2
Odessa	15811,5	13395,8	19152,2	6995,5
Kherson	–	–	–	–

Source: compiled on the basis of information materials of the Main Department of Statistics in Mykolayiv, Odesa and Kherson regions.

In the Black Sea economic region, the situation with investment in measures aimed at protecting air and climate change is deteriorating. Thus, according to the State Statistics Service of Ukraine, the share of capital investment in air protection and climate change in the economic region in 2020 amounted to 29.7% of total capital investment in all types of environmental measures, decreasing compared to 2010 by 19 percentage points. The share of capital investments in the district decreased in 2010-2020 by 1.3 percentage points. or from 3.8 to 2.5% of the total volume of capital investments in the relevant type of environmental measures.

The largest share of capital investments in protection of atmospheric air and problems of climate change falls on the Nikolaev area (94,9% of total volume in the area); then comes the Odessa region (5.08%) and Kherson (0.02%). The share of capital investments in air protection and problems of climate change in the Nikolaev area decreased by 26,3 percentage points or from 66.1 to 39.8% of capital investment for all types of environmental measures in the region, in Odessa – by 35.2 percentage points or from 40.8 to 5.6%, in Kherson – by 10 percentage points or from 10.3 to 0.3% (*Table 31*).

Table 31

Dynamics of capital investments in air protection and climate change problems in the Black Sea region, *thousand UAH (in actual prices*)

Years	Total volume	*Including by regions*		
		Mykolayiv	Odessa	Kherson
2010	43561,5	20661,5	22610,9	289,1
2011	30278,5	13040,9	16778,7	458,9
2012	34553,1	30596,2	3739,1	217,8
2013	20177,6	8505,8	11270,9	400,9
2014	25508,0	17384,2	5472,1	2651,7
2015	50376,0	36344,4	10717,5	3314,1

2016	39975,4	27972,3	11938,8	64,3
2017	48629,3	35035,7	13208,4	385,2
2018	34205,1	17430,1	16587,3	187,7
2019	37775,1	12354,9	25371,3	48,9
2020	138888,7	131842,0	7019,1	27,6

Source: compiled on the basis of information materials of the Main Department of Statistics in Mykolayiv, Odesa and Kherson regions; section "Environment" of the official website of the State Statistics Service of Ukraine.

It should be noted that the situation with financing the development of the waste management system in the economic region is better. Thus, the share of capital investment in waste management in 2020 was 33.5% of total capital investment in all types of environmental measures, which is 30 percentage points higher than in 2010. The share of capital investment in the area increased in 2010-2020 at 4.7 percentage points. or from 0.7 to 5.4% of the total Ukrainian capital investment for the relevant type of environmental measures. Thus the share of capital investments in waste management in the Nikolaev area increased for this period by 45,4 percentage points. or from 46.1 to 91.5% of the total volume of these investments in the Black Sea economic region. But in the Odessa region the value of this indicator decreased by 22.9 percentage points (from 28.9 to 6%), and in Kherson – by 22.5 percentage points (from 25 to 2.5% of the total amount of capital investment data in the region) (*Table 32*).

Table 32

Dynamics of capital investments in waste management in the Black Sea region, *thousand UAH (at actual prices)*

Years	Total volume	*Including by regions*		
		Mykolayiv	Odessa	Kherson
2010	3141,7	1449,7	908,7	783,3
2011	30253,7	20724,9	8949,9	578,9
2012	18529,4	13877,5	4428,3	223,6
2013	24753,1	20580,4	3998,0	174,7
2014	29899,0	27618,4	2210,6	70,0
2015	53242,4	51024,8	1995,3	222,3
2016	71059,6	69412,5	1639,8	7,3
2017	47585,2	44002,3	3419,3	163,6
2018	65372,4	54970,4	9067,6	1334,4
2019	58854,8	53655,2	4743,5	456,1
2020	156611,8	143375,6	9341,3	3894,9

Source: compiled on the basis of information materials of the Main Department of Statistics in Mykolayiv, Odesa and Kherson regions; section "Environment" of the official website of the State Statistics Service of Ukraine.

During 2010-2020, the share of current expenditures on air protection and climate change in the economic region increased by 1.4 percentage points. or from 1.8 to 3.2% of total current expenditures for all types of environmental measures. During this period, the share of current expenditures in the Black Sea region decreased by 1.8 percentage points. or from 3.6 to 1.8% of the total Ukrainian current expenditures for the relevant type of environmental measures. Thus the greatest share of current expenses for protection of atmospheric air and problems of climate change falls on the Nikolaev area (54,5% of total volume in the area); followed by Odessa region (41.6%) and Kherson region (3.9%).

Table 33

Dynamics of current expenditures for air protection and climate change problems in the Black Sea region, *thousand UAH (in actual prices)*

Years	Total volume	*Including by regions*		
		Mykolayiv	Odessa	Kherson
2010	17092,3	9553,1	5325,8	2213,4
2011	15414,9	5623,6	7693,5	2097,8
2012	17089,2	7338,2	8091,9	1659,1
2013	13049,6	6464,6	5060,1	1524,9
2014	23667,6	11789,9	10671,3	1206,4
2015	19491,5	7002,6	10256,3	2232,6
2016	26789,1	10687,9	14544,4	1556,8
2017	29610,2	12739,5	15158,5	1712,2
2018	33064,7	11046,0	19917,3	2101,4
2019	32116,8	16330,0	13544,3	2242,5
2020	51350,6	27989,1	21374,4	1987,1

Source: compiled on the basis of information materials of the Main Department of Statistics in Mykolayiv, Odesa and Kherson regions; section "Environment" of the official website of the State Statistics Service of Ukraine.

The share of current expenditures on air protection and climate change in the Kherson region decreased by 9 percentage points. or from 12.9 to 3.9% of the unit costs for all types of environmental measures in the region; in Mykolayiv – by 1.4 percentage points or from 55.9 to 54.5%. And in the Odessa region, on the contrary, increased by 10.4 percentage points or from 31.2 to 41.6% (*Table 33*).

Table 34

Dynamics of current costs of waste management in the Black Sea region, *thousand UAH (in actual prices)*

Years	Total volume	*Including by regions*		
		Mykolayiv	Odessa	Kherson
2010	156114,4	35061,2	114082,9	6970,3
2011	478686,0	363616,9	92007,1	23062,0
2012	163306,5	94080,9	54495,0	14730,6
2013	228962,6	133883,4	86523,2	8556,0
2014	650301,5	573128,2	68715,7	8457,6
2015	1355207,2	1294337,9	49730,3	11139,0
2016	1271326,5	1128842,0	131373,7	11110,8
2017	1317335,0	1179222,9	121464,7	16647,4
2018	612222,0	431369,0	166772,5	14080,5
2019	768817,6	541463,1	214043,9	13310,6
2020	443629,1	210178,2	216686,6	16764,3

Source: compiled on the basis of information materials of the Main Department of Statistics in Mykolayiv, Odesa and Kherson regions; section "Environment" of the official website of the State Statistics Service of Ukraine.

Statistical analysis shows that the share of current expenditures on waste management in 2020 was 27.3% of current expenditures on environmental protection for all types of environmental measures or 10.7 percentage points more than in 2010. The share of current expenditures in the Black Sea region decreased in 2010-2020 by 2 percentage points or from 6 to 4% of the total Ukrainian current expenditures for the relevant type of environmental measures. The share of current expenses for waste management in the Nikolaev area increased for this period by 24,9 percentage points or from 22.5 to 47.4% of the total current expenditures in the region. However, in the Odessa region, the value of this indicator decreased by 24.3 percentage points (from 73.1 to 48.8%), and in Kherson – by 0.7 percentage points or from 4.5 to 3.8% (*Table 34*).

The share of investments in the overhaul of fixed assets for environmental protection in the Black Sea economic region decreased in 2019 compared to 2010 by 2 percentage points or from 4.1 to 2.1% of the total volume of such investments in Ukraine. Thus in the Nikolaev area, since 2018 investments in capital repairs of fixed assets of nature protection stopped. In 2010 the share of these investments in the Nikolaev area made 51,4% of total regional volume. The share of investments in the overhaul of fixed assets for environmental purposes in the Odessa region increased by 54.9 percentage points or from 40.8 to 95.7% of their volume in the region. But the value of this indicator in the Kherson region, on the contrary, decreased by 35 percentage points or from 7.8 to 4.3% (*Table 35*).

Table 35

Investments in capital repairs of fixed assets for environmental protection in the Black Sea region, *thousand UAH*

Years	Total volume	*Including by regions*		
		Mykolayiv	Odessa	Kherson
2010	20323,6	10436,7	8299,8	1587,1
2011	30177,1	2088,6	26419,5	1669,0
2012	15804,9	37,0	15146,4	621,5
2013	7517,8	1083,5	3305,6	3128,7
2014	13835,3	7283,8	1897,5	4654,0
2015	13600,0	2900,0	4500,0	6200,0
2017	78300,0	300,0	77200,0	800,0
2018	10800,0	0,0	9700,0	1100,0
2019	30300,0	-	29000,0	1300,0

Source: compiled on the basis of information materials of the section "Environment" of the official website of the State Statistics Service of Ukraine; statistical collection "Environment of Ukraine 2019".

The analysis of the approved Strategies of regional development for the period till 2027 shows that the priority directions include preservation of the natural environment, ecotransformation, increase of level of ecological safety of territories. These strategic documents are consistent with the main aspects of regional development, namely: the approximation of quality of life to European standards and the development of human potential; increasing the competitiveness of the region's economy; sustainable development of settlements and communities.

Thus, the results of previous studies (Yu. Zaloznova, A. Kwilinski, N. Trushkina, 2018; S. Ivanov, V. Liashenko, N. Trushkina, 2019; S. Ivanov, V. Liashenko, N. Trushkina, 2020; M. Hryhorak, N. Trushkina, 2020; H. Dźwigoł,

A. Kwilinski, N. Trushkina, 2021; N. Trushkina, H. Dzwigol, A. Kwilinski, 2021; Yu. Drachuk, N. Trushkina, O. Serhieieva, Ye. Snitko, G. Belyaeva, 2021) and the conducted statistical analysis indicate an insufficiently successful transformation of the regional transport and logistics system in the Black Sea region in the context of the green economy. This is primarily due to limited funding for the modernization of transport and logistics infrastructure and insufficient implementation of green technologies.

Given that, it is advisable to develop and implement a mechanism for "green" investment in infrastructure projects, which means financing investments that provide environmental benefits in the broad context of environmentally sustainable development of various areas of economic activity. According to expert estimates, only 1% of global bonds are marked as "green", while 1% of investments of institutional investors belong to the category of "green" infrastructure assets (G 20 Green Finance Study Group, 2016). To date, among foreign and domestic researchers and practitioners there is no single approach to the classification of funding instruments for "green" projects, including the transport sector (*Table 36*).

Table 36

Approaches to the classification of funding instruments for "green" projects proposed by various scientific schools

Scientific schools representatives	Types of funding instruments
S. Venugopal A. Srivastava C. Polycarp E. Taylor, 2012	- mechanisms of public support; - public financing instruments: loans, share capital, investment instruments that exclude risks
N. Lindenberg, 2014	- instruments through which direct financing is carried out: shares, credit lines, loans and grants; - instruments that do not provide direct funding, but can transfer knowledge or reduce risks: guarantees and technical assistance; - instruments used to attract additional private resources transferred to "green" projects through one of the above instruments: green bonds and structured funds
M. Voica M. Panait I. Radulescu, 2015	- green shares; - green bonds
V. Kazlauskiene A. Draksaite L. Melnyk, 2017	- green bonds; - green shares; - green loans; - budget financing instruments

Source: compiled by the authors.

Thus, the key instruments for "green" financing the modernization of transport infrastructure, which are effectively used in different countries around the world, include:

"green" bonds – bonds of any type, income from the placement of which are aimed exclusively at full or partial financing or refinancing of new and launched "green" projects that meet the established requirements (France, Brazil, China);

"green" loans – loans of any type, provided exclusively for full or partial financing or refinancing of new and launched "green" projects that meet the established requirements;

green investment funds – a mutual investment fund or other investment mechanism that provides investments only in companies that are considered socially conscious in terms of their business activities or directly contribute to the development of social responsibility using standardized "green" assets (France, Switzerland, United Kingdom).

Statistical analysis shows that the global volume of sustainable financing assets increased in 2016-2018 by 34.1%, including in Europe – by 17.5%, the United States - by 37.9%, Canada – by 54.5%, Australia and New Zealand – by 40%. The largest share of sustainable financing assets falls on Europe (45.9% of global assets) and the United States (39.1%) (*Table 37*).

Table 37

Global distribution of sustainable investment assets, *trillion dollars USA*

Regions	Year	
	2016	2018
Europe	12,0	14,1
USA	8,7	12,0
Japan	0,5	2,2
Canada	1,1	1,7
Australia and New Zealand	0,5	0,7
Total	22,9	30,7

Source: Global Sustainable Investment Review – Global Sustainable Investment Alliance, 2018.

At the same time, as noted in the analytical report (K. Markevych, V. Sidenko, 2019) in European countries, the most widely used investment approach is "negative screening"; in the USA, Canada, Australia and New Zealand – "integration of ESG-factors"; in Japan - "corporate interaction and shareholder action".

There is a growing trend of investment in some "green" investment approaches in the world. Thus, the volume of thematic sustainable investment increased 3.7 times in 2016-2018; positive screening – 2.3 times; targeted investment – 2 times; integration of ESG-factors – 1.7 times; negative screening – 1.3 times; corporate management and actions of shareholders – 1.2 times (*Table 38*).

Table 38

Volumes of investment in some "green" investment approaches in the world, *billion dollars USA*

Approaches	Year	
	2016	2018
Targeted investment	224,5	444,3
Thematic sustainable investment	276,2	1017,7
Positive screening	818,0	1841,9
Screening within normal limits	6195,4	4679,4
Corporate management and actions of shareholders	8385,2	9834,6
Integration of ESG-factors	10353,2	17543,8
Negative screening	15063,6	19771,0

Source: Global Sustainable Investment Review – Global Sustainable Investment Alliance, 2018.

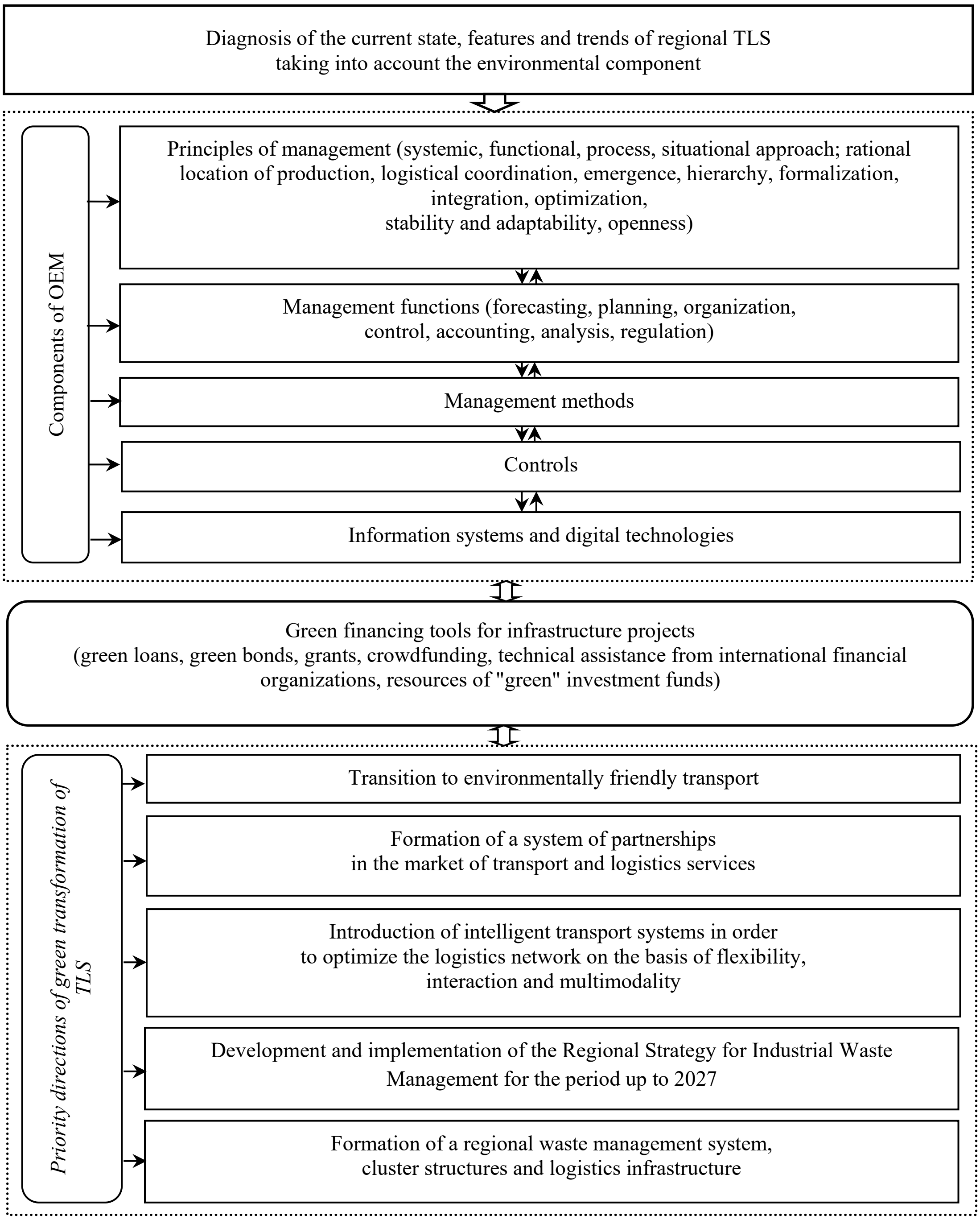


Figure 67. – Structural and logical scheme of transformation of the regional transport and logistics system on the basis of green economy *(author's development)*

As a result of research (O. Krylova, 2017; O. Serhieieva, 2017a; O. Serhieieva, 2017b; O. Krylova, 2018; O. Krylova, 2019; N. Trushkina, 2019; N. Trushkina, 2020; H. Dzwigol, N. Trushkina, A. Kwilinski, 2021) it is established that for the effective functioning of the regional transport and logistics system (TLS) of the Black Sea region in the context of "green" growth, it is advisable to apply a comprehensive approach (*Fig.67*). Its essence is to integrate the main components of the organizational and economic mechanism (principles, functions, methods, tools, management tools, information systems and technologies) and green financing tools for the implementation of priority areas of green transformation of TLS.

In the current conditions of rapid development of the green economy, the issues of environmental protection in the transport sector and in the organization of logistics activities in the Black Sea region are relevant. Therefore, today regional and local governments and participants in supply chains should pay special attention to environmental factors in the process of formation and operation of the transport and logistics system. This will be in line with the main provisions of the Green Pact for Europe. At the same time, the study revealed numerous manifestations of non-compliance of the regional transport and logistics system of the Black Sea Economic Region with international environmental standards and requirements, including the level of greening of logistics activities in the world.

Thus, based on the above, we can conclude that it is appropriate to apply in modern Ukrainian realities of international practice of implementing the mechanism of "green" investment in infrastructure projects. For this purpose it is necessary to make corresponding changes and additions to the National transport strategy of Ukraine for the period till 2030 and Strategy of regional development of the Nikolaev, Odessa and Kherson areas for the period 2021-2027. This will successfully transform the transport and logistics system of the Black Sea region on the basis of a green economy and achieve a balanced sustainable development of transport infrastructure through the introduction of investment-attractive "green" solutions.

REFERENCES

72. Drachuk, Yu., Trushkina, N., Serhieieva, O., Snitko, Ye., & Belyaeva, G. (2021). Standardization of Business Processes in the Transportation Sector. *Open Journal of Business and Management*, 9, 2312-2328. https://doi.org/10.4236/ojbm.2021.95125.
73. Dźwigoł, H., Kwilinski, A., Trushkina, N. (2021). Green Logistics as a Sustainable Development Concept of Logistics Systems in a Circular Economy. *Proceedings of the 37th International Business Information Management Association (IBIMA)*, 1-2 April 2021 (pp. 10862-10874). Cordoba, Spain: IBIMA Publishing.
74. Dzwigol, H., Trushkina, N., Kwilinski, A. (2021). The Organizational and Economic Mechanism of Implementing the Concept of Green Logistics. *Virtual Economics*, 4(2), 74-108. https://doi.org/10.34021/ve.2021.04.02(3).
75. G 20 Green Finance Study Group. Green Finance Synthesis Report (2016). http://g20.org/English/Documents/Current/201608/PO20160815359441639994.pdf.
76. Global Sustainable Investment Review – Global Sustainable Investment Alliance (2018). http://www.gsi-alliance.org/wp-content/uploads/2019/03/GSIR_Review2018.3.28.pdf.
77. Hryhorak, M. Yu., Trushkina, N. V. (2020). Development of the logistics system of the economic region “Polissya” in the context of the green economy:

ecological problems and perspectives". *Intellectualization of logistics and Supply Chain Management*, 4, 27-40. https://doi.org/10.46783/smart-scm/2020-4-3.

78. Ivanov, S. V., Liashenko, V. I., Trushkina, N. V. (2019). Peredumovy formuvannia ta perspektyvy rozvytku transportno-lohistychnoho klastera v Prychornomorskomu ekonomichnomu raioni [Prerequisites for the Formation and Prospects of Development of the Transport and Logistics Cluster in the Black Sea Economic Region]. *Black Sea Economic Studies*, *46*(2), 16-24. https://doi.org/10.32843/bses.46-25 (in Ukrainian).
79. Ivanov, S. V., Liashenko, V. I., Trushkina, N. V. (2020). Pravovi aspekty stvorennia transportno-lohistychnykh klasteriv v rehionakh Ukrainy [Legal aspects of creating transport and logistics clusters in the regions of Ukraine]. *Gesellschaftsrechtliche Transformationen von wirtschaftlichen Systemen in den Zeiten der Neo-Industrialisierung*: Collective monograph (pp. 661-668). Nüremberg: Verlag SWG imex GmbH (in Ukrainian).
80. Jianwei, Z., Minjie, Z., Liwei, Z. (2011). Research on System Constitution of the Logistics Ecological Environment. *Procedia Engineering*, 15, 375-380. https://doi.org/10.1016/j.proeng.2011.08.072.
81. Kazlauskiene, V., Draksaite, A., Melnyk, L. (2017). Green investment financing alternatives. *Proceedings of the 2017 International Conference Economic Science for Rural Development* (27-28 April 2017). Jelgava, LLU ESAF, 46. 250-257.
82. Krylova, O.V. (2017). Financializaion and economic crisis. Ekonomichnyi visnyk Natsionalnoho hirnychoho universytetu. 2017. https://ev.nmu.org.ua/docs/2017/1/EV20171_146-155.pdf.
83. Krylova, O. V. (2018). Zovnishni ta vnutrishni ryzyky finansovo-kredytnoi stabilnosti v Ukraini [External and Internal Risks of Financial and Credit Stability in Ukraine]. In *Vzaiemodiia bankiv ta inshykh ustanov z pidpryiemstvamy: teoriia, metodyka i praktychna realnist* (pp. 114-124). Dnipro: Porohy (in Ukrainian).
84. Krylova, O. V. (2019). Stratehiia rozvytku ta osoblyvosti funktsionuvannia finansovo kredytnoi systemy Ukrainy [Development Strategy and Features of Functioning of the Financial and Credit System of Ukraine]. In *Teoriia ta metodolohiia formuvannia investytsiinofinansovoi stratehii rozvytku subiektiv natsionalnoho hospodarstva* (pp. 89-102). Dnipro: Zhurfond (in Ukrainian).
85. Lindenberg, N. (2014). Public Instruments to Leverage Private Capital for Green Investments in Developing Countries. *Discussion Paper*. German Development Institute.
86. Liu, W., Wei, W., Yan, X., Dong, D., Chen, Z. (2020). Sustainability risk management in a smart logistics ecological chain: An evaluation framework based on social network analysis. *Journal of Cleaner Production*, 276, Article 124189. https://doi.org/10.1016/j.jclepro.2020.124189.
87. Markevych, K. Sidenko, V. (2019). «Zeleni» investytsii u stalomu rozvytku svitovyi dosvid ta ukrainskyi kontekst ["Green" investments in sustainable

development world experience and Ukrainian context]. Kyiv: Zapovit (in Ukrainian).

88. Moroz, M., Polkowski, Z. (2016). The Last Mile Issue and Urban Logistics: Choosing Parcel Machines in the Context of the Ecological Attitudes of the Y Generation Consumers Purchasing Online. *Transportation Research Procedia*, 16, 378-393. https://doi.org/10.1016/j.trpro.2016.11.036.
89. Pulawska, S., Starowicz, W. (2014). Ecological Urban Logistics in the Historical Centers of Cities. *Procedia – Social and Behavioral Sciences*, 151, 282-294. https://doi.org/10.1016/j.sbspro.2014.10.026.
90. Serhieieva, O. R. (2017). Suchasnyi stan hlobalnoi ekonomiky v svitovomu hospodarstvi [the Current State of the Global Economy in the World Economy]. *Investytsii: praktyka ta dosvid*, 11, 32-37 (in Ukrainian).
91. Serhieieva, O. R. (2017). Tsinova polityka v systemi zabezpechennia konkurentospromozhnosti pidpryiemstva [Pricing Policy in the System of Ensuring the Competitiveness of the Enterprise]. *Pryazovskyi ekonomichnyi visnyk*, *4*(04), 56-60 (in Ukrainian).
92. Simão, L. E., Gonçalves, M. B., Rodriguez, C. M. T. (2016). An approach to assess logistics and ecological supply chain performance using postponement strategies. *Ecological Indicators*, 63, 398-408. https://doi.org/10.1016/ j.ecolind.2015.10.048.
93. Trushkina, N. V. (2019). Transformatsiia transportno-lohistychnoi systemy v Ukraini na zasadakh zelenoi lohistyky [Transformation of the transport and logistics system in Ukraine on the basis of green logistics]. *Economic Herald of the Donbas*, *2*(56), 151-161. https://doi.org/10.12958/1817-3772-2019-2(56)-151-161 (in Ukrainian).
94. Trushkina, N. (2020). «Zelene» investuvannia rozvytku transportno-lohistychnoi systemy: svitova praktyka ["Green" investing in the development of transport and logistics system: world practice]. *Conference Proceedings of the International Scientific Online Conference Topical Issues of Society Development in the Turbulence Conditions* (May 30, 2020, Bratislava) (pp. 207-215). Bratislava: The School of Economics and Management in Public Administration in Bratislava (in Ukrainian).
95. Trushkina, N., Dzwigol, H., Kwilinski, A. (2021). Cluster model of organizing logistics in the region (on the example of the economic district "Podillya"). *Journal of European Economy*, *20*(1), 127-145. https://doi.org/10.35774/ jee2021.01.127.
96. Urbanyi-Popiołeka, I. (2019). Cruise industry in the Baltic Sea Region, the challenges for ports in the context of sustainable logistics and ecological aspects. *Transportation Research Procedia*, 39, 544-553. https://doi.org/10.1016/ j.trpro.2019.06.056.
97. Venugopal, S., Srivastava, A., Polycarp, C., Taylor, E. (2012). Public Financing Instruments to Leverage Private Capital for Climate-Relevant Investment: Focus on Multilateral Agencies. *Working paper*. World Resources Institute.

98. Voica, M.C., Panait, M., Radulescu, I. (2015). Green Investments – between Necessity, Fiscal Constraints and Profit. *Procedia Economics and Finance*, 22. 72-79.
99. Zaloznova, Yu., Kwilinski, A., Trushkina, N. (2018). Reverse logistics in a system of the circular economy: theoretical aspect. *Economic Herald of the Donbas, 4*(54), 29-37.

VI. THE ROLE OF DIGITAL TOOLS IN COMBATING NEW CHALLENGES OF NATURE

Olha Pizhuk
Doctor of Sciences (Economics),
Associate professor of Enterprise economy department
State Tax University, Irpin'
E-mail: opizhuk@gmail.com
ORCID 0000-0002-5802-1053

Iryna Mynchynska
PhD (Economics),
Senior Lecturer of Enterprise Economy Department
State Tax University, Irpin'
E-mail: mynchynska@gmail.com
ORCID 0000-0003-2221-7860

6.1. The economics of climate change

An overwhelming body of scientific evidence now clearly indicates that climate change is a serious and urgent issue. Climate change is one of three main issues, together with demographic changes (increasing proportion of the elderly population) and rapid technological progress, which have a significant impact on the economy [1]. At the beginning of the XXI century, the scale of climate change reached such a level that it became a powerful factor influencing not only certain sectors of the economy, but also global economic processes and socio-economic development of society, food and energy security.

Climate change describes the current trend toward higher average global temperatures and accompanying environmental shifts such as rising maximum and minimum temperatures, rising sea levels, higher ocean temperatures, an increase in heavy precipitation (heavy rain and hail), shrinking glaciers, thawing permafrost. In coming decades, climate change – and efforts to limit that change and adapt to it – will have more and more serious consequences both for the economies of individual countries and for the world economy as a whole (Figure 68).

As well as its serious impact on the environment and people, climate change is one of the biggest threats to economic stability. Heatwaves make us less able to work and reduce productivity. Hurricanes, cyclones and typhoons devastate millions of people, leaving them in absolute poverty after ruthlessly sweeping away their communities. Droughts shrink harvests, further complicating the arduous task of feeding the world population, which is expected to reach 10 billion by 2050 [2]. The World Bank is warning: if we don't do something immediately, climate change could push 100 million more people into poverty by 2030.

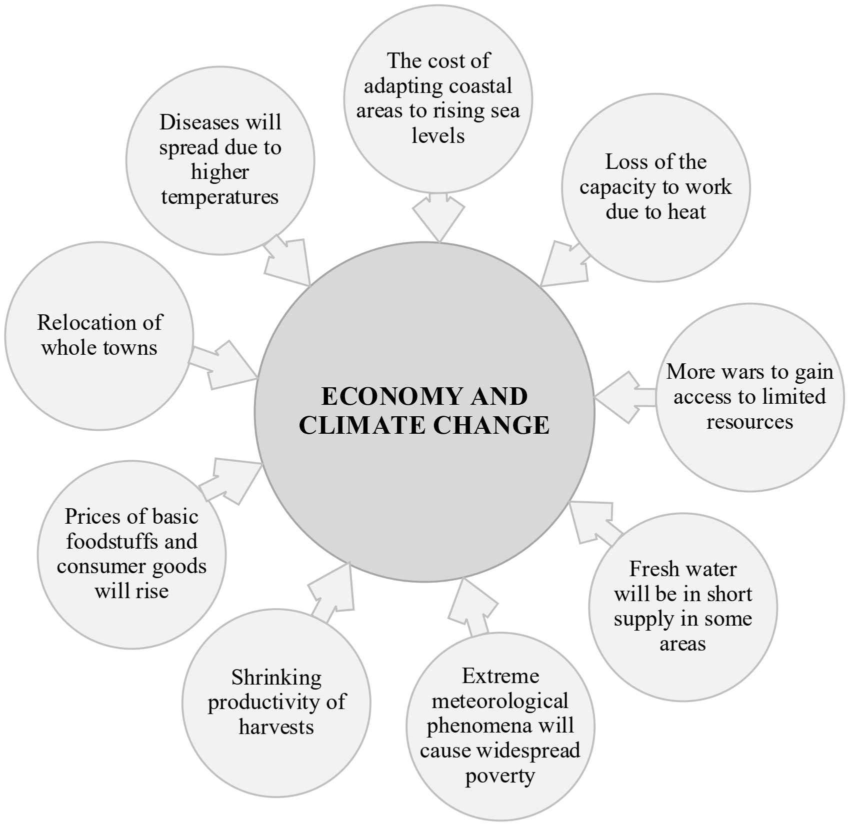


Figure 68. The social and economic impact of climate change
Source: How is climate change affecting the economy and society? Iberdrola, SA. 2021. https://www.iberdrola.com/environment/impacts-of-climate-change

Climate Change and Security Risks. Besides, climate change is also at the heart of the peace and security agenda of the 21st century. There is an emerging global consensus that climate change will stress the economic, social, and political systems that underpin each nation state.

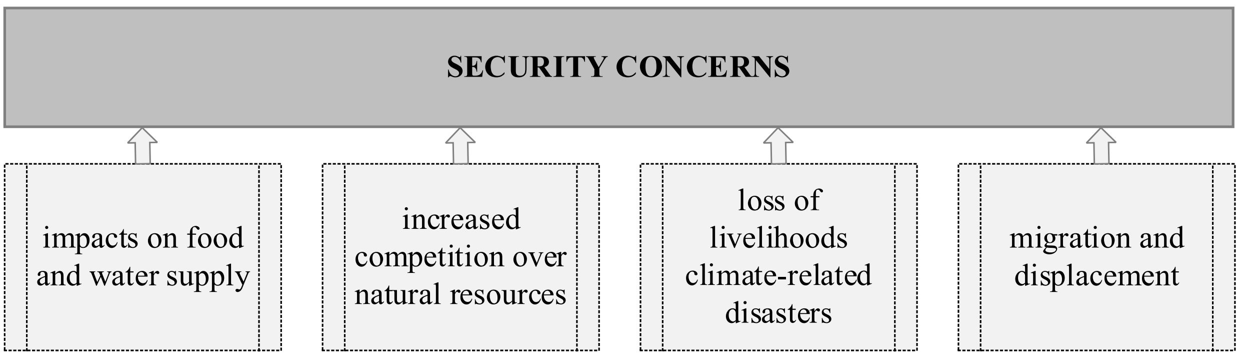


Figure 69. Security concerns aggravated by climate change
Source: Climate Chance & Security. Strengthening Resilience to Climate-Fragility Risks. UN Environment Assembly and Governing Council, 2021. https://www.unep.org/explore-topics/disasters-conflicts

Risks of climate variability affecting security [3]:
- Local resource competition;
- Livelihood insecurity and migration;
- Extreme weather events and disasters;

- Volatile food prices and provision;
- Transboundary water management;
- Sea-level rise and coastal degradation;
- Unintended effects of climate policies.

The ultimate ‘threat multiplier’, climate change worsens existing social, economic and environmental risks that can fuel unrest and potentially result in violent conflict (Figure 69).

Where institutions and governments are unable to manage the stress or absorb the shocks of a changing climate, the risks to the stability of states and societies will increase. The global economy could lose 10% of its total economic value by 2050 due to climate change, according to research [4]. However, this figure could rise significantly to 18% of gross domestic product (GDP) by mid-century if no action is taken and temperatures rise by 3.2°C. Climate change impacts displayed by Swiss Re Institute's Climate Economics Index. The Swiss Re Institute’s Climate Economics Index stress tests how global warming will affect 48 countries – representing 90% of the world economy – and ranks their climate resilience (Table 39).

Table 39

Impact of global temperature rise on GDP in all regions by mid-century

	Temperature rise scenario, by mid-century			
	Well-below 2°C increase	**2.0°C increase**	**2.6°C increase**	**3.2°C increase**
	Paris target	The likely range of global temperature gains		Severe case
	Simulating for economic loss impacts from rising temperatures in % GDP, relative to a world without climate change (0°C)			
World	- 4,2	- 11,0	- 13,9	- 18,1
OECD	- 3,1	- 7,6	- 8,1	- 10,6
North America	- 3,1	- 6,9	- 7,4	- 9,5
South America	- 4,1	- 10,8	- 13,0	- 17,0
Europe	- 2,8	- 7,7	- 8,0	- 10,5
Middle East & Africa	- 4,7	- 14,0	- 21,5	- 27,6
Asia	- 5,5	- 14,9	- 20,4	- 26,5
- Advanced Asia	- 3,3	- 9,5	- 11,7	- 15,4
- ASEAN	- 4,2	- 17,0	- 29,0	- 37,4
Oceania	- 4,3	- 11,2	- 12,3	- 16,3

Note: Temperature increases are from pre-industrial times to mid-century, and relate to increasing emissions and/or increasing climate sensitivity (reaction of temperatures to emissions) from left to right.
Source: Swiss Re Institute. The economics of climate change: no action not an option April 2021. https://www.swissre.com/dam/jcr:e73ee7c3-7f83-4c17-a2b8-8ef23a8d3312/swiss-re-institute-expertise-publication-economics-of-climate-change.pdf

Generally, expected global GDP impact by 2050 under different scenarios compared to a world without climate change: 18% if no mitigating actions are taken (3.2°C increase); 14% if some mitigating actions are taken (2.6°C increase); 11% if further mitigating actions are taken (2°C increase); 4% if Paris Agreement targets are met (below 2°C increase). The Climate Economics Index stress-tests impact all countries, but some are more vulnerable than others (Figure 69).

Figure 69. Heat map of countries ranked by the Total Climate Economics Index

Note: Total Index includes GDP impact, sea level rise, crop yield, heat stress, health, tourism.

Source: The economics of climate change. Swiss Re Institute. Swiss Re Institute. https://www.swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/expertise-publication-economics-of-climate-change.html

As global warming makes the impact of weather-related natural disasters more severe, it can lead to substantial income and productivity losses over time. For example, rising sea levels result in loss of land that could have otherwise been used productively and heat stress can lead to crop failures.

Some of the many negative predicted effects are [5]:

– Loss of land area, including beaches and wetlands, because of sea-level rise;
– Loss of species and forest area;
– Disruption of water supplies to cities and agriculture;
– Increased air conditioning costs;
– Health damage and deaths from heat waves and spread of tropical diseases;
– Loss of agricultural output due to drought.

Emerging economies in equatorial regions would be most affected by rising temperatures. Economies in South and South-east Asia were the most susceptible to the physical risks associated with global warming. The impact of climate change has been forecasted to be the hardest hit for Asian economies, with a 5.5% hit to GDP in the best-case scenario, and 26.5% hit in a severe scenario. However, there were significant regional variations in the data. Advanced Asian economies are predicted to see GDP losses of 3.3% in case of a below-2°C rise and 15.4% in a severe scenario, while ASEAN countries are forecast to see drops of 4.2% and 37.4% respectively. Countries most negatively impacted – including Malaysia, Thailand, India, the Philippines and Indonesia – were often the ones with the least resources to mitigate and adapt to the effects of global warming. China is at risk of losing nearly 24% of its GDP in a severe scenario compared to forecast losses of 10% for the US, Canada and the UK and 11% for Europe. The Middle East & Africa, meanwhile, would see a drop of 4.7% if temperature rises stay below 2°C and 27.6°C in the severe case scenario.

Table 40

Possible Effects of Climate Change

Temp rise (°C)	1°C	2°C	3°C	4°C	5°C	More than 5°C
Water	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Potentially 20-30% decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	In Southern Europe, serious droughts occur once every 10 years 1-4 billion more people suffer water shortages, while 1-5 billion gain water, which may increase flood risk	Potentially 30-50% decrease in water availability in Southern Africa and Mediterranean	Possible disappearance of large glaciers in Himalayas, affecting one-quarter of China`s population and hundreds of millions in India	The latest science suggests that the Earth' s average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and
Food	Modest increases in cereal yields intemperate regions	Sharp declines in crop yield in tropical regions (5-10% in Africa)	150-550 additional millions at risk of hunger (if carbon fertilization weak) Agricultural yields in higher latitudes likely to peak	Agricultural yields decline by 15-35% in Africa, and entire regions out of production (e.g. parts of Australia)	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks	
Health	At least 300,000 people each year die from climate related diseases (predominantly diarrhea, malaria, and malnutrition) Reduction in winter mortality in higher latitudes (Northern Europe, USA)	40–60 million more people exposed to malaria in Africa	1–3 million more people die from malnutrition (if carbon fertilization weak)	Up to 80 million more people exposed to malaria in Africa		
Land	Permafrost thawing damages buildings and roads in parts of Canada and	Up to 10 million more people affected by coastal flooding each	1–170 million more people affected by coastal flooding each year	7–300 million more people affected by coastal flooding	Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world	

	Russia	year		each year	cities such as New York, London, and Tokyo	
Environment	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef	15–40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou	20–50% of species facing extinction (according to one estimate), including 25–60% mammals, 30–40% birds and 15–70% butterflies in South Africa Collapse of Amazon rainforest (according to some models)	Loss of around half Arctic tundra Around half of all the world's nature reserves cannot fulfill objectives		
Abrupt and Large-Scale Impacts	Atlantic Thermohaline Circulation starts to weaken	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7 m sea level rise Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon Rising risk of collapse of West Antarctic Ice Sheet Rising risk of collapse of Atlantic Thermohaline Circulation				

Source: Stern, N. (2006). "Stern Review on The Economics of Climate Change (pre-publication edition). Part II Impacts of Climate Change on Growth and Development". HM Treasury, London. Archived from the original on 31 January 2010. Retrieved 31 January 2010. https://webarchive.nationalarchives.gov.uk/ukgwa/20100407173011mp_/http://www.hm-treasury.gov.uk/d/Part_II_Introduction_group.pdf

However, such nations also have the most to gain from global efforts to reduce temperature rises. Some beneficial outcomes might include [6]:

– Increased agricultural production in cold climates;
– Lower heating costs;
– Fewer deaths from exposure to cold.

The potentially beneficial outcomes would be experienced primarily in northern parts of the Northern hemisphere, such as Iceland, Siberia and Canada. Most of the rest of the world, especially tropical and semi-tropical areas, are likely to experience strongly negative effects from additional warming. According to IPCC projections, with increasing emissions and higher temperatures, negative effects will intensify and positive effects diminish (Table 40).

Other less-predictable but possibly more damaging and permanent effects include [6]:

– Disruption of weather patterns, with increased frequency of hurricanes, droughts, and other extreme weather events.

– A possible rapid collapse of the Greenland and West Antarctic Ice Sheets, which would raise sea levels by 12 meters or more, drowning major coastal cities.

– Sudden major climate changes, such as a shift in the Atlantic Gulf Stream, which could change the climate of Europe to that of Alaska.

– Positive feedback effects, such as an increased release of CO_2 from warming arctic tundra, which would speed up global warming.

The effect of climate change on growth and inflation. Despite there being winners and losers, increasing temperatures will be negative for global activity overall.

The overall aggregate effect of climate change on economic growth will most likely be negative in the long run. Although there will be winners and losers from climate change at varying levels of warming, the impact of rising temperatures will be widespread, in part due to the financial, political and economic integration of the world's economies. Global warming will primarily influence economic growth through damage to property and infrastructure, lost productivity, mass migration and security threats [7]. The balance between winners and losers turns increasingly negative as temperatures rise.

Global warming is expected to increase the frequency and severity of extreme weather events, bringing with it property and infrastructure loss. The likes of Hurricane Sandy, which flooded much of New York in 2012, are prime examples of the economic damage such extreme weather events can cause. Rising sea levels will also likely harm economic output as businesses become impaired and people suffer damage to their homes.

While the initial economic response to recover this damage may be positive for GDP (when it is possible to do so), once it is recognized that such events are a permanent feature of the environment, the world economy faces an extreme challenge. Many will find that it is not worth replacing capital stock unless measures can be taken to prevent future damage, or there is an opportunity to move the business to safer ground. At best, this could involve a short period of disruption as businesses relocate; at worst, a permanent loss of capital stock and output. As the temperatures continue to climb, the damage will become increasingly permanent [7].

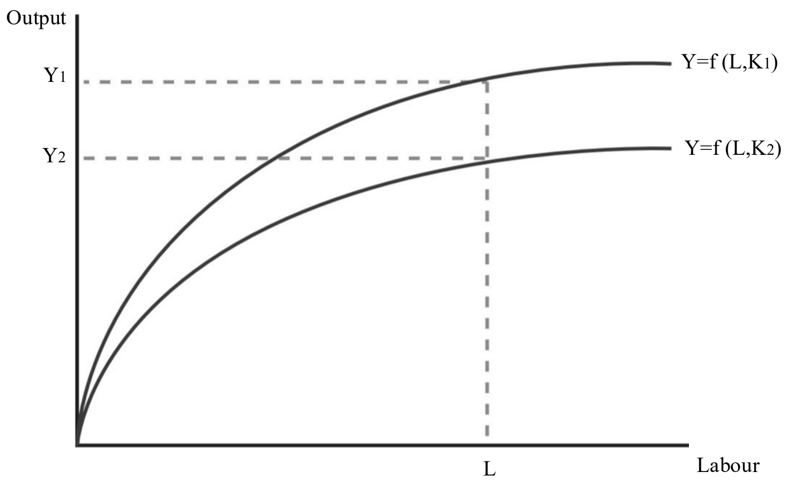


Figure 70. Global production function

Source: Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf

Using a production function (Figure 70), we can demonstrate the likely effect climate change will have on output. If we assume less capital stock is available due to the damage inflicted from climate change, we would see a fall in the productive capacity of the world economy. This would translate into a downward shift in the world production function as each unit of labor produces less output. Lower labor productivity may not just occur due to a lower level of capital stock, however. Higher global temperatures may affect food security, promote the spread of infectious diseases and impair those working outdoors. Such factors are likely to cause greater incapacity and social unrest and as a result will reduce both the effectiveness (productivity) and the amount of labor available to produce output.

This effect can also be expressed as a supply shock through a supply and demand framework (Figure 71). Global warming is likely to contract supply at any given price and result in a backward shift of the supply curve (from S_1 to S_2). As the diagram demonstrates, this will result in a lower level of output (Y_2) and, as we discuss in the next section, a higher price (P_2).

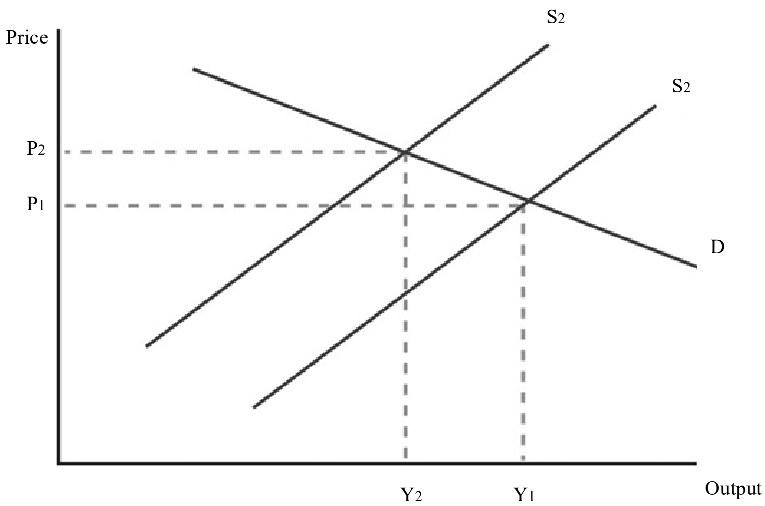


Figure 71: Supply and demand effects

Source: Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf

There is also an opportunity cost to be considered. The above analysis is based on "all else equal" argument whereby the world's population is seen not to respond to climate change. It is probable that over time, preventative measures such as flood defenses are put in place in order to avoid the costs of climate change. While this may reduce the long-term economic consequences, there is likely to be a short-term economic cost to this action as resources are directed away from more productive uses. The biggest threat climate change poses to economic growth is from immediate, aggressive and inefficient mitigation policies [8]. The process of adaptation and mitigation will require a temporary economic transition from consumption to investment, with the argument being that the transitional costs are small relative to the cost of inaction. Mitigation costs could reach 1% of global GDP per year by 2050 [9]. However, we would argue that as the costs of mitigation rise, budget constraints are likely to become increasingly important. Governments may be unable to raise the capital necessary to build adequate defenses, for example.

The above supply and demand diagram not only shows a reduction in output, but an increase in the general price level as a result of global warming. This leads us onto the possible inflationary effects of global warming on the world economy.

Agricultural yields are sensitive to weather conditions and as our climate becomes ever more extreme, more frequent droughts may reduce crop yields in areas where food production is vital. Higher global food prices will likely thus squeeze consumers' income in the process. We must acknowledge that these effects will be partially offset as other regions becoming more suitable for crop production and new drought resistant crops are developed. However, in aggregate, and as the level of warming becomes even greater, food price inflation should rise [7].

Rising inflation may also materialize through reduced land availability. The surge in global temperatures may eventually cause some areas of the world to become uninhabitable and with this will come mass migration. Alongside the political and socioeconomic implications of these moves will be higher demand for an ever decreasing amount of land. In essence, the world's population will be forced to live in an increasingly concentrated space. In similar fashion to food inflation however, this effect will also be moderated by some areas of land becoming more habitable.

Higher energy costs are also likely to boost inflation. As our climate becomes more extreme we are likely to demand greater energy to both cool our working and living environments during the summer, and heat them when we experience harsher winters. Not only will energy demand change, but supply may shrink as the efficiency of existing power stations is compromised due to higher temperatures. Policy actions by governments to encourage a transition to green energy may further contribute to energy inflation in the short- to medium-term whereby taxes are placed on fossil fuel-derived electricity. Given that energy forms the basis of most of the world's production, the secondary effects of higher energy prices on inflation will be felt throughout the global economy. Conversely, depending on the pace of change, the greater prominence of renewable energy could limit the cost of energy increases going forward.

The insurance industry recognizes that it is likely to bear much of the risk of global warming. Companies have already felt the force of extreme weather events on profits; from unseasonal floods in the UK to Hurricane Katrina in the US, extreme weather-related damage to properties has seen insurance companies pay out to cover these costs. It is believed that 2011 was the most expensive year on record for natural disasters, with insured losses costing the industry more than $126 billion [7]. Climate change is one of the top risks faced by the insurance industry.

The industry has been at the forefront of assessing climate risk, and as a consequence, the costs of global warming could be felt earlier than expected in the form of higher premiums. We are already seeing a curtailment of available cover in areas such as Florida and many Gulf coast states for example. The cost of flood insurance has risen significantly in the UK. Rising insurance costs add to inflation and will deter firms and households from locating in areas at risk. From this perspective, the costs of climate change are already being incorporated into business decisions and in this way are already affecting global activity. Insurance companies may go as far as to refuse to provide insurance cover, posing a challenge for governments who may either have to underwrite, and/or mitigate the risk of damage.

Climate damage functions: quantifying the impact on activity. Early estimates of the cost of global warming on world GDP emerged in the early 1990s and since then there have been a number of studies that have both agreed with and contradicted the initial assessments. Howard Covington and Raj Thamotheram [10] base their analysis on so called "climate damage functions" that quantify the risk the economy faces as a result of climate change. Economic climate damage is defined as the fractional loss in annual economic output at a given level of warming compared to output in the same economy with no warming. Climate damage functions plot the level of output lost over a range of warming estimates, with all functions predicting a greater loss in annual economic output as the level of warming rises. However, among the estimated climate damage functions there is a lack of consensus as to how damages evolve as warming gradually increases. The following figure and table summarize a number of estimated economic damage functions, named after their respective originators. We briefly discuss each climate damage function below, focusing on the 4°C mark given that the World Bank estimates there is a 40% chance of exceeding this level by 2100, assuming emissions follow a "medium business-as usual pathway" [7].

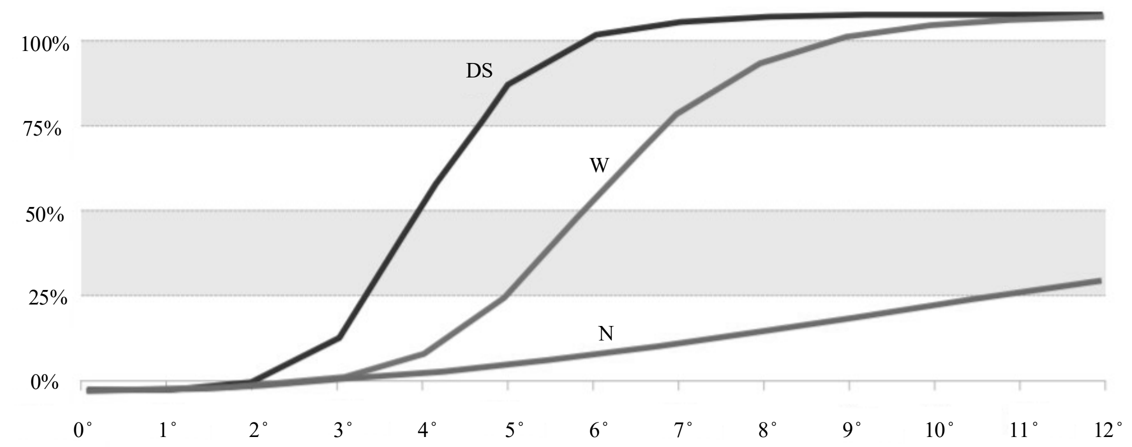


Figure 72. Climate damage functions

Note: Climate damage forecasts at a given level of warming based on estimates by Dietz and Stern (2014), Weitzman (2012) and Nordhaus (2013).

Source: Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf

Climate damage functions: quantifying the impact on activity. Early estimates of the cost of global warming on world GDP emerged in the early 1990s and since then there have been a number of studies that have both agreed with and contradicted the initial assessments. Covington H. and Thamotheram R. [10] base their analysis on so called "climate damage functions" that quantify the risk the economy faces as a result of climate change. Economic climate damage is defined as the fractional loss in annual economic output at a given level of warming compared to output in the same economy with no warming. Climate damage functions plot the level of output lost over a range of warming estimates, with all functions predicting a greater loss in annual economic output as the level of warming rises. However, among the estimated climate damage functions there is a lack of consensus as to how damages evolve as warming gradually increases. The estimated functions of economic damage are given below (Figure 72, Table 41). Consider each of the climate damage functions, focusing on the 4°C mark given that the World Bank estimates there is a 40% chance of exceeding this level by 2100, assuming emissions follow a "medium business-as usual pathway".

Table 41

Climate change functions

Warming	**Climate damage**		
	DS-damages	W-damages	N-damages
1˚	0 %	0 %	0 %
2˚	2 %	1 %	1 %
3˚	14 %	3 %	2 %
4˚	50 %	9 %	4 %
5˚	81 %	25 %	7 %

Note: Estimates of climate damage at varying degrees of warming. Climate damage is defined as the fractional loss in annual economic output at a given level of warming compared to output in the same economy with no warming.
Source: Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf

Estimates of climate change damage vary according to whether there is a tipping point at which damage accelerates.

The "N-damages" climate damage function, named after its originator William Nordhaus [11], is widely used by economists and is the least concerning of the three climate damage functions. Climate damage under this function would be progressive whereby no tipping point is reached and the world's population has the greatest amount of time to offset any negative effects of global warming. It can be seen that by the year in which the world is 4°C warmer, annual economic output will be just 4% lower than a base case with no warming. The baseline case in Nordhaus's study is for warming of around 3.8% by 2100. Nordhaus W. believes the economic impact of climate change is likely to be small over the next couple of decades and that agriculture is the most exposed sector to global warming. Although the cumulative effects are reasonable at the point at which 4°C is reached, the loss in terms of average annual growth would be extremely small and difficult to distinguish given that it will take many decades to reach 4°C of warming based on current estimates [7].

The "W-damages" function was produced by Martin Weitzman [12] and estimates that by the time 4°C of warming is reached, 9% of annual economic output will be lost relative to the base with no warming effect. Under this scenario, those industries that are largely predisposed to climate change risk globally are likely to be affected, for example insurance, agriculture and forestry. However, Davig W. Pearce et al [13] believe that only a fraction of the market economy is vulnerable to global warming, namely agriculture, coastal resources, energy, forestry, tourism, and water. These sectors contribute just 5% of global GDP to which their share is expected to shrink overtime [8].

This can be seen when we translate the damage function into the effect on economic growth. If we assume a base case of 3% annual economic growth and that 4°C warming is reached by 2080, we find that annual growth will be pared back to 2.85%. This is based on an economy that is 9% smaller due to climate damage in 2080 relative to an economy with no warming. An effective loss of 0.15% per annum could be seen to warrant some attention from policymakers and the government alike, but is unlikely to be sufficiently powerful to prompt a significant response to climate change [7].

Table 42

Estimates of economic losses from climate change

Study	Warming	Impact (% on GDP)	Comment
Mendelsohn, Schlesinger, Morrison and Andronova (2000)	2.0° by 2060	A cumulative effect of a loss of 0.3% of GDP in 2060	Assuming 2°C of warming is reached by 2060, most damages will come from agriculture. OECD economies will gain from warming while the rest of the world will lose. Damages to individual countries do not always follow continental averages. The Ricardian model predicts much smaller losses and gains than the reduced-form model, predicting a 0.04% net gain to 2060 GDP levels from 2.0°C warming.
Mendelsohn, Schlesinger and Williams (2000)	2.5°C by 2100	Cumulative market impact costs do not exceed 0.1% of GDP in 2100	The market impact costs will vary from country to country across the globe. High-latitude countries are expected to gain and low latitude countries are forecast to be harmed by warming. However, temperature effects beyond 2°C are expected to reduce benefits and increase damages.
Stern (2005)	Baseline scenario of between 2.4°C and 5.8° by 2100	An average loss of 5% of global GDP per annum over the next two centuries	Estimates are based on no action. Costs increase to 20% of GDP or more if a wider range of risks and impacts are considered. Based on simple extrapolations, costs of extreme weather alone could reach 0.5-1% of world GDP per annum by the middle of the century.
Intergovernmental Panel on Climate Change, Fifth Assessment (2014)	Approximately 2.0°C	A loss of 0.2%-2.0% of GDP per annum	There are large differences between countries when damage estimates accelerate beyond 3°C of warming. Delaying mitigation efforts beyond those currently in place to 2030 is estimates to substantially increase the difficulty of transitioning to low long-term emission levels.

Source: Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf

The final climate damage function, "DS-damages", named after Simon Dietz and Nicholas Stern [14] is the most extreme scenario in which the global economy would suffer considerable loss as a result of climate change. Under this scenario, as and when warming extends to 4°C, annual economic output will be 50% lower compared to a scenario where no warming occurs. To put this into perspective, Dietz and Stern estimate warming of approximately 3.5°C by 2100. If we take a stricter approach however, using the same assumptions as the W-damages function above but assuming 4°C is reached in 2080, the base case 3% annual economic growth rate falls to just 1.9% a year. At this rate, climate change is set to have a noticeable impact on future growth and living standards. Reaching a tipping point at 2-3°C, as Dietz S. and Stern N. [14] predict, could therefore be seen as a crucial stage of warming for the global economy whereby the costs of insufficient action significantly weigh on growth.

Some additional comparative studies in the literature aimed at examining the economic impacts of climate change are summarized in Table 4. Similar to the damage functions described above and aside from the Stern review and upper estimates from the Intergovernmental Panel on Climate Change (IPCC), the consensus is that the economic costs of marginal warming will be small up to 2°C but begin to gather pace if we move toward 4°C.

This analysis indicates that output losses accelerate once warming exceeds 2°C, but that these effects are not likely to be felt for another 30 years. It is this threshold which is apparent in investment studies such as that recently published by Mercer which finds negative returns to diversified portfolios once warming breaches 2°C. However, let us not forget that warming unfolds over time and that actions today have implications for the future. Since the process is largely irreversible over the medium term, the global economy can be seen to have committed to a certain degree of future warming already. A 2014 World Bank study titled "Turn Down the Heat. Confronting the New Climate Normal" estimates that warming of close to 1.5°C above pre-industrial times is locked into the earth's atmospheric system and is thus unavoidable [7]. According to the same study, without reasonable action to reduce emissions, the earth is on track for 2°C warming by mid-century and 4°C or more by the end of the century. Stern N. [9] also estimates that without action to reduce emissions, the concentration of greenhouse gases could double their pre-industrial levels as early as 2035, almost committing the world to temperature increases of over 2°C.

For investors assessing the value of a stream of income, these projections are critical and we would suggest using a range of climate damage functions given the uncertainty over each. Expressing future economic losses in today's prices requires discounting the loss in output back to the present day. By its nature, small changes in the discount rate cause large changes in loss estimates given the very long time horizon in which climate change is expected to occur. When attempting to quantify the impact climate change will have on a diversified portfolio, Covington H. and Thamotheram R. [10] use a discount rate of 6.5%. In contrast the Stern N. review [9] uses 1.4% (0.1% above expected consumption growth), so it is unsurprising that

Stern's estimates forecast greater costs of climate change than many other studies. Given the decline in long-term interest rates since the Global Financial Crisis, it seems using a rate toward the lower end of recent studies would be reasonable.

Despite the initial reticence of the business community, an increasing number of studies and activities show that measures aimed at dealing with global climate change are a golden opportunity for ensuring sustainable development and driving economic growth. As explained by the World Commission on the Economy and Climate in a report at the end of 2018 [15], adopting ambitious climate action measures may generate profits of USD$26 billion by 2030, creating 65 million new jobs with low carbon emissions.

According to this report, to build a more resilient, beneficial growth model for people we must accelerate structural transformation in five key economic sectors [16]:

1. Clean energy systems. Decarbonisation of the energy system coupled with decentralised, digitised electrification technologies could give a billion more people access to modern energy services.

2. Smarter urban developments. More compact, connected and coordinated cities would save US$ 17 billion by 2050 and stimulate economic growth by improving access to work and housing.

3. Sustainable land use. A switch to more sustainable farming methods combined with strict forestry protection could generate economic benefits of around 2 billion dollars per year.

4. Smart water management. In areas with a water shortage, GNP could fall by up to 6% in 2050. This could be prevented by making more efficient use of water through technological improvements and investment in public infrastructure.

5. Circular industrial economy. Today, 95% of the value of the material from plastic packaging - up to 120 billion dollars a year - is lost after the first use. Policies that encourage more circular and efficient use of materials could improve global economic activity and reduce waste and pollution.

At the same time, the Global Commission on the Economy and Climate is urging public and private sector leaders to take these urgent measures in the next two or three years: put a price on carbon and force companies to disclose climate-related financial risks, speed up investment in sustainable infrastructure, harness the power of the private sector, boosting innovation and increasing the transparency of the value chain, and adopt a people-centric focus to ensure equitable growth and a fair transition.

6.2. The role of digital technologies in addressing climate neutrality

Today we observe a convergence of two seemingly different trends that have consequences for economic theory and practice [17]. The first trend relates to the heightened attention to the climate emergency [18; 19; 20; 21]. Earth's distressing situation has been brought to the fore by diverse stakeholders. In particular, in 2019, Ripple and colleagues (2020) warned of a climate emergency. They presented graphs of planetary vital signs indicating very troubling trends and little progress by humanity to address climate change. Based on these data and scientists' moral obligation to "clearly warn humanity of any catastrophic threat," they called for transformative change. The European parliament recently followed the UK and Canadian governments in declaring a climate emergency. In business, companies are voluntarily or under the pressure of investors, governments, and other stakeholders, committing to ambitious environmental goals because this is the sustainability imperative [22; 23; 24]. In popular media, Netflix and David Attenborough's "Our Planet" and a wave of activists are raising awareness among the general public.

The second trend involves the rapid digitalization of the economy. Artificial intelligence and machine learning (AI/ML) are advancing exponentially, and both businesses and governments are competing in a race to harness its potential. While PwC [25] estimates AI will add some 14% – or USD 15.7 trillion – to the global economy by 2030, observers raise concerns ranging from adverse employment impacts to the ethical implications of AI-based decision making [26]. As AI/ML begins rapidly altering resource allocations within and across economies, the Internet of Things (IoT) promises to connect billions of devices in webs of autonomous communication. The resulting "smart" houses, transportation systems, electricity grids, and cities will increase economic flows by lowering transaction costs [27] in ways that make lives easier and increase welfare. And simultaneously, distributed ledgers or blockchains are resurfacing from their initial hype with a promise to reorganize transactions in fairer, more decentralized, open access, efficient, and reliable ways [28]. Some insiders consider blockchain so transformative it will instigate the next "infrastructure inversion" – the previous three being driven by steam, electricity, and the Internet – that will fundamentally alter the global economic and institutional infrastructure and our very social fabric [29]. These technologies usually have been identified as key drivers of digitalization [30].

The convergence of sustainability (climate emergency) and digital imperatives is beginning to gain traction. Digital technology is playing an increasingly important role in measures to mitigate climate change. It has the potential to deliver almost half (46%) of the emissions savings required by 2030 [31]. A study produced by GSMA and the Carbon Trust has found that mobile technology has enabled a global reduction in greenhouse gas emissions of over 2 billion tonnes of CO_2 in 2018, a saving ten times higher than the global carbon footprint of the mobile industry itself [32]. Digitalization is based on electricity. This means its overall impact on greenhouse gases and on CO_2 emissions, in particular, depends on the mix of energy sources used, which varies considerably depending on location and circumstances.

The different greenhouse gases have different global warming potentials. Since CO_2 makes up the bulk of these gases, the concept of CO_2 equivalent (CO_2e) is used as a proxy to express the impact of all greenhouse gases that are emitted on climate change. These emissions include the extraction of the required raw materials, manufacturing processes and the transport and distribution of products. We can distinguish between direct and indirect emissions in companies' value chains. The latter can be divided into upstream direct emissions, such as goods and services sourced from external suppliers, their transport to the company, the use of assets like offices and data centres, and business trips and employee travel, and downstream indirect emissions, which include the transport, distribution, use and end-of-life processing of products, in addition to investments and leased assets. The direct effects associated with the life cycle and use of ICT devices are known as their environmental footprint, a concept that encompasses their carbon footprint. The Greenhouse Gas Protocol classifies these emissions as scope one (direct), scope two (indirect related to energy consumption) and scope three (other indirect).

However, while reliable statistics are available on energy production, it is much harder to find accurate data on consumption by key sectors and harder still to find figures on the energy consumption associated with the production of specific goods. In the case of digitalisation, the energy incorporated into products is part of the environmental price we pay for everything we own and use, and plays a part in reducing emissions derived from the associated production of electricity and manufacture of peripherals. The lack of metrics to monitor the evolution of greenhouse gas emissions that take into account both changes in the electricity mix and the role of the carbon incorporated into the equipment associated with devices in the various sectors of ICT (data centres, networks and user devices) is a major issue.

The carbon footprint of the ICT sector in 2018 was 730 million tonnes of CO_2, almost equivalent to the 800 million tonnes of CO_2 produced by the fuel burnt by the aviation industry (80% of which is associated with travel). However, there is a huge difference in the number of users: approximately 70% of the world's population use ICT, while just 10% use aviation services. The emissions from the fuel used by one person on a transatlantic return flight are estimated to be equivalent to 50 years of use of a smartphone (including the use of networks and data centres). Holding international meetings online clearly has significant potential to reduce emissions.

Will renewable energies decarbonise ICT? As we shall see further on, the ICT sector is striving to increase its use of renewable energy, which has helped reduce its emissions. This change is necessary, together with increased renewable energy capacity, since all sectors will need to replace fossil fuels with renewable sources. However, renewable energy itself has a significant carbon footprint embedded in its infrastructure and supply chains, albeit much less than fossil fuels. According to the recent commitment by the European Commission, achieving the ambitions of carbon neutrality for data centres by 2030 will require an absolute cap on absolute energy consumption, in addition to a higher proportion of renewable energy.

We must distinguish between the direct and indirect effects of digitalisation when it comes to greenhouse gases. Direct effects encompass the manufacture of products, the corresponding facilities and their use. All these aspects have their own electricity consumption, although new developments in technology, which have run in parallel to the rise of digitalisation, are helping reduce this consumption.

The current results are promising for the three main components:

(a) Data centres can accommodate the rise in Internet traffic without increasing the energy demand.

(b) Networks as a whole have maintained low levels of greenhouse gas emissions.

(c) The various user devices.

In terms of the absolute figures for these emissions, the German institute Bitkom has published a study with data for 2018:

- Data centres use 160 ± 25 million tonnes of CO_2e;
- Mobile networks use 54 ± 13 million tonnes of CO_2e;
- Optical networks use 83 ± 20 million tonnes of CO_2e;
- Devices use 460 ± 110 million tonnes of CO_2e.

The estimates published by Bitkom, which are backed by other studies cited in the report, show that user devices as a whole have a higher carbon footprint than data centres and networks, with the particular feature that the impact of the manufacture of these devices is higher than their use. Apple estimates the carbon footprint of each new iPhone to be 70-85 kg of CO_2e.

The main conclusion that can be drawn from all of this is that, despite our fears, current trends show there is significant potential for the infrastructure that is currently installed – or that may be installed in the future – to meet the rising demand for data traffic without increasing the carbon footprint of ICT. The effects of efficiency improvements must be able to outpace or at least cancel outgrowth. Indirect effects come from the environmental impact of the production and consumption of digital devices and may be harmful, depending on how they are manufactured. In this respect, the growing programmed obsolescence of many of these devices undermines their sustainability, meaning lifespans and recycling must be increased.

Digitalisation alone will not have a sufficient impact on consumption patterns to address climate change. The fact is that changes in these patterns are often produced solely in response to price. In the case of ICT, this cost is relatively low. One example of an indirect reduction in greenhouse gas emissions is the use mentioned above of videoconferencing systems to replace in-person meetings, with Forbes estimating that the pandemic could permanently reduce business travel by 10%. Another example is teleworking, which was already growing but experienced a boom during the pandemic. In principle, as many studies have confirmed, avoiding travel saves greenhouse gas emissions, although other studies have also disputed this claim.

One of the indirect impacts of digital technology – a positive for climate change mitigation– is its potential to reduce the emissions of other activities (e.g., transport, manufacturing, agriculture, buildings, construction and energy), with the European Commission estimating savings of up to 12.1%.

New data from Bitkom, in partnership with the consultancy firm Accenture, shows that for the four groups examined so far (industrialization, mobility, building and teleworking), accelerating digitalization could deliver almost half (46%) of the CO_2e savings required by 2030. Moreover, this figure could increase to over 50% with the incorporation of the energy, agriculture and public services sectors, whose digitalization also has the potential to reduce the corresponding carbon footprint. The report notes that not only will acceleration in digitalization help protect the environment and the climate, but it will also make the German economy –and, by extension, the EU as a whole– more competitive. Digitalization has the potential to square the circle of economic growth and environmental and climate protection. The study found that digitalization could save one in five tonnes of CO_2.

As noted, the carbon footprint of digitalization can be significantly reduced by increasing the use of renewable energy for ICT equipment. Various studies corroborate the contribution digital technology can make to sustainability in areas such as electricity and heating (efficient buildings controlled by AI and using smart meters to change consumption), industrial production, agriculture and media and publishing.

It should be stressed that these digital technologies play a crucial role in the ecological transition. In line with the Paris Agreement, the European Commission envisages using these technologies for these purposes. The Digital Spain 2025 agenda states that digitalization 'will also be a driver of the other major transition that must be addressed by our society: the ecological transition to a new economic and social model based on sustainability. One of the goals is to accelerate the digitalization of the productive model through projects to bring about sectoral transformations with structural effects (aiming for a 10% reduction in CO_2 emissions as a result of digitalization). According to the World Economic Forum, digital services have the potential to reduce energy and materials throughout the economy and could directly facilitate a significant reduction (15%) in emissions by 2030.

For example, last year, Google began using AI to make wind energy more predictable – and thus more valuable– in a number of its renewable energy projects. The initial results have shown that AI has increased the value of its wind energy by 20%. The company has also used machine learning to help people decide whether to fit solar panels on their roofs after mapping over 107 million roofs in over 21,000 cities. Companies like Google are also studying dynamically distributing their computational capacity across data processing centres where the supply of energy comes from a higher percentage of renewable sources.

The remainder of this section will focus on three digital technologies with the potential to contribute to carbonization or decarbonization if designed and used correctly: (a) big data, data science and AI; (b) the Internet of Things (highly dependent on 5G networks); and (c) blockchain. While developments in the transport sector (which makes up 21% of global emissions, 73% of which come from short journeys) has shown how technology can have positive effects in different areas (virtual, shared and smart mobility), this is slightly different to the concept of digitalization being discussed here. Another example is streaming services, such as video and music, which have a significant environmental impact.

Big data is made possible by the gathering and storing of data from multiple sources and the powerful computational resources of the cloud (which, despite the name's celestial connotations is based on the data processing centres of an all too earthly world). There is significant interest in interpreting these large and complex datasets through data science and AI, which play a central role in the vision of a ‘smart future’ with less carbon and smart networks, cities, logistics, agriculture and homes. Sometimes referred to as the ‘new oil’, big data has already had a commercial impact. However, the carbon footprint of the growing energy consumption of storage and data centres makes big data prohibitive if its electricity does not come from clean sources. This has led many companies to opt for renewable forms of energy and the European Commission to include it as an aspect of its data strategies.

It has been shown that AI and its computationally complex algorithms operating on big data (especially with the machine and deep learning) can emit 284 tonnes of CO_2 to train just one machine learning algorithm for natural language processing, an impact five times higher than the lifetime emissions of running a car. Neural networks significantly increase the carbon footprint of AI: without them, it has a carbon footprint of just 650kg, compared with 285 tonnes with them. As Fernando Mateo notes, neural networks improve AI performance but at the high environmental cost of operating the supercomputers needed for the calculations. This order of magnitude means that unless all energy comes from clean sources, this growth (an exponential doubling every four months) will not be compatible with addressing the climate crisis.

This increase in computation underlines the need for ‘green’ AI, focusing on increasing the energy efficiency of calculations, in contrast to the current ‘brown’ AI. Unfortunately, sustainability is one of the most under-represented issues in AI ethics guidelines. For example, it was absent from the OECD guidelines and the G20’s 2019 guidelines. Nonetheless, as we have noted, companies, governments and organisations like the EU are insisting more and more on this dimension, even if – in the case of the latter two – only in a general manner and without specific proposals.

The Internet of Things (IoT) refers to everyday and other objects that are connected to the Internet via mobile terminals that control domestic appliances, vehicles (autonomous or otherwise) and industries and is one of the fastest developing areas. Its applications are classed as ‘smart technology’, especially when combined with data science and AI to optimise the use of energy. For example, IoT services based on the location and analysis of data from smart cities can reduce pollution from transport through more efficient routes and improve logistics by reducing energy requirements. There are expected to be over 75 billion devices connected to the Internet by 2025, compared to 15 billion in 2015.

The impact of IoT is closely linked to the development of 5G networks, which offer lower latency and faster speeds. There are many examples of potential synergies between the two technologies to reduce greenhouse gas emissions, provided IoT applications replace and do not supplement more traditional carbon-intensive activities. However, the growing dependency on 5G networks is set to increase total energy consumption by between 150% and 170% by 2026, a figure that represents between 5% and 13% of annual electricity consumption. These emissions are already covered by the EU Emissions Trading System (EU ETS). According to a report produced by the French Senate, this market-based mechanism theoretically guarantees that the 5G rollout will fit the negotiated quotas. However, it does not guarantee compliance, a significant source of concern in the country.

Blockchain technology is based on decentralised databases designed to prevent centralised authority or a central point that can fail or be tampered with using a range of cryptographic techniques. Blockchain algorithms are dependent on high levels of replication and redundancy, which means their energy consumption is extremely high.

Cryptocurrencies like Bitcoin, which are based on this technology, consume large amounts of electricity. For example, according to Digiconomist, which has created a Bitcoin Energy Consumption Index, one Bitcoin transaction is equivalent to 735,121 Visa transactions or 55,280 hours spent watching YouTube. This makes the type of energy consumed key. Assuming that other cryptocurrencies have the same carbon intensity as Bitcoin, the carbon footprint of all these currencies would be 69 $MtCO_2$, the equivalent of 0.1% of global emissions. The vast majority of Bitcoin miners are located in China. For example, it has been calculated that blockchain mining operations could consume as much energy and produce the same amount of carbon emissions as in certain European countries like the Czech Republic. At the same time, a British study found Bitcoin consumes more energy than Argentina.

If unchecked, these trends could drive growth that is unlikely to be offset by reductions in greenhouse gas emissions enabled by ICT in other sectors, including blockchain itself, which is finding an increasing number of applications, including the traceability of “green” hydrogen. There is also the future development of official digital currencies, such as the euro, the yuan, the yen and the dollar, which will use part of these technologies but whose effects on the climate have not been widely discussed.

Climate neutrality refers to the idea of achieving net zero greenhouse gas emissions by balancing those emissions, so they are equal (or less than) the emissions that get removed through the planet’s natural absorption. Most national and international climate goals are aiming for net zero by either 2030 or 2050. To reach it, we need to reduce emissions by as much as we can as fast as possible. Digital is a proven accelerator of change in every facet of society. The technologies already exist and can be deployed immediately.

Digital technology is uniquely positioned to provide and enable tools that can be used to mitigate GHG emissions and adapt and build resilience to the impacts of climate change. This section explores the role of digitalization in driving energy efficiency gains across the buildings, manufacturing, transportation and others.

Smarter Energy Use in Buildings. Residential and commercial buildings account for one-third of global energy demand and 55 % of electricity consumption. These numbers are even higher in the United States, where buildings are the largest energy-consuming sector, consuming 71 % of the nation’s electricity. In U.S. homes and apartments, cooling, heating, and water heating together account for nearly two-thirds of total final energy demand, with lighting, appliances and electronics, refrigeration, and clothes drying rounding out the remainder. Commercial-building energy use is more evenly split between cooling, ventilation, lighting, refrigeration, and office equipment, with each accounting for about 20 % of the whole [33].

Digitalization of building energy systems and consumer devices can greatly improve the energy efficiency of buildings by ensuring energy is consumed when and where it is needed, and improving the responsiveness of energy services (e.g., lighting, air conditioning). Sensors enable homeowners and commercial building managers to predict, measure, and monitor the real-time energy performance of buildings, allowing consumers to identify where energy savings can be achieved. Active controls can optimize energy use within a building while also enabling better integration with the power grid. Benefits include lower energy costs for homeowners and building managers, greater consumer choice, improved reliability and resilience, improved integration of distributed energy resources such as rooftop solar, avoided electricity capacity buildouts, and reduced environmental impacts.

Sensors and controllers are platform technologies that can be integrated into all building energy systems to enable greater connectivity and systems-level optimizations. One study found that integrating smart sensors and controls throughout the commercial building stock has the potential to save as much as 29 % of building energy consumption through high-performance sequencing of operations, optimizing settings based on occupancy patterns, and detecting and diagnosing inadequate equipment operation and installation problems. Smart sensors and controls can enable buildings to reduce their peak electricity load by 10 to 20 %, e.g., by shifting some energy services to times of day when energy demand is low. The U.S. Department of Energy (DOE) estimated that sensor and control technologies alone could reduce building energy consumption in the United States by 1.7 quads in 2030, generating $18 billion in annual energy savings [34].

Table 43

U.S. commercial building subsector energy savings from smart building technologies

Building type	Floor area (sq. ft.)	Smart building technology	Avg energy consumption (kWh/year)	Percent savings	Avg savings (kWh/year)
Education	100,000	Occupancy sensors Web-based lighting control management systems	190,000	11	20,900
Office	50,000	Lighting controls Remote HVAC control systems	850,000	23	200,000
Hotel	200,000	Guest room occupancy controls	4,200,000	6	260,000
Laboratory	70,000	Air-quality sensors. Occupancy sensors. Real-time ventilation controllers	980,000	40	390,000
Hospital	120,000	Lighting controls + LED upgrades. Data analytics software packages	7,900,000	18	1,400,000

Source: Colin Cunliff (2020) Beyond the Energy Techlash: The Real Climate Impacts of Information Technology https://itif.org/publications/2020/07/06/beyond-energy-techlash-real-climate-impacts-information-technology

Heating, ventilation, and cooling (HVAC) is the largest energy demand in a building, typically consuming 40 % of a commercial building's energy. Smart HVAC systems can use sensors and active controls to optimize airflow and conditioning based on data such as occupancy, temperature, humidity, and air pressure. Variable-frequency drives attached to rooftop air conditioning units optimize the supply of airflow, which can thereby reduce electricity consumption by up to 50 %. Smart thermostats that help households and building managers monitor and regulate heating and cooling can reduce electricity demand by 15 to 50 %, depending on the building and control technology.

These findings concord well with a 2017 report from ACEEE that found U.S. commercial buildings could reduce their annual energy use by 6 to 40 %, depending on the building type (Table 43). The report identifies a suite of smart technologies, the energy savings for each technology, and the associated capital costs and payback periods. The technologies ranged from smart thermostats and variable drive HVAC systems to smart plugs that turn off devices when they are no longer in use to advanced and web-based lighting controls. In many cases, the payback time for installing these technologies was on the order of 1 to 3 years.

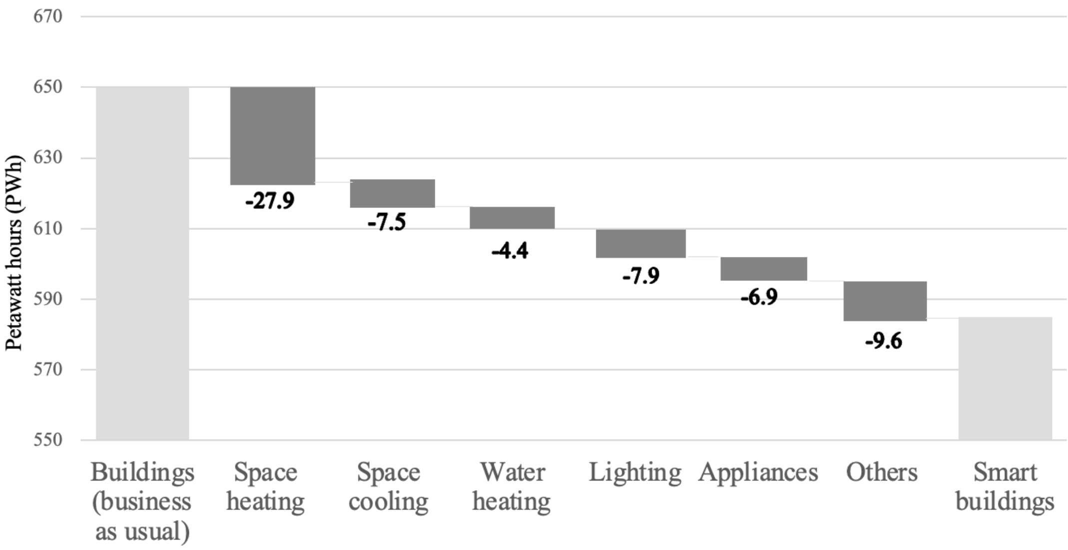


Figure 73. Cumulative (2017–2040) energy savings in buildings from widespread digitalization, by energy use

Source: ITIF adaptation of IEA, Cumulative energy savings in buildings from widespread digitalisation in selected countries, 2017–2040, IEA, Paris, https://www.iea.org/data-and-statistics/charts/cumulative-energy-savings-in-buildings-from-widespread-digitalisation-in-selected-countries-2017-2040.

IEA's 2017 report "Digitalization and Energy" identifies the global potential energy savings from smarter energy use in buildings. IEA projected electricity use in buildings will nearly double from 11 petawatt hours (PWh) in 2014 to around 20 PWh in 2040. But integration of ICT can moderate that growth, reducing annual electricity use by up to 4.65 PWh, or nearly 25 %. The active controls needed to make building systems smarter would consume only 275 TWh annually, far less than the energy saved by those controls. Cumulative global electricity savings between now and 2040 is roughly 65 PWh, with the United States saving 14 PWh. The largest potential savings come from heating, cooling, and lighting, which make up more than 60 % of total final energy demand in buildings (Figure 73).

In 2019, DOE launched a new research initiative to develop grid-interactive buildings that can provide greater systems-level efficiencies and demand-management services. The initiative is based on the principle that building end uses can be dynamically managed to help meet grid needs and minimize electricity system costs, while meeting occupants' comfort and productivity requirements. The initiative is also aimed at co-optimizing distributed energy resources such as rooftop solar, battery and thermal energy storage, and combined heat and power with building energy systems. DOE identified four demand-side management services networked and connected building energy systems can provide to the grid.

Efficiency – the ongoing reduction in energy use:

- Load Shed – the ability to reduce electricity use for a short period of time, typically during peak demand periods or emergencies;
- Load Shift – the ability to change the timing of electricity use, for reasons such as minimizing demand during peak periods, taking advantage of low electricity prices, or reducing the need for renewable curtailment;
- Modulate – the ability to balance power supply/demand autonomously on a second to sub-second scale to maintain power quality (e.g., frequency).

A key benefit grid-integrated buildings can provide is demand response. In comparison with efficiency strategies that are insensitive to timing, and primarily aim to reduce cumulative building energy consumption, demand response focuses on shedding or shifting electricity demand during peak hours (top right and bottom left in, when electricity is usually most expensive. For the customer, load shifting has the benefit of reducing electricity costs. For utilities, demand response avoids the buildout of "peaker plants" – typically natural gas combustion turbines – which run for only a few hours during the year. Demand response can also enable greater integration of variable renewable energy from wind and solar by shifting energy loads to periods of renewable availability, thereby avoiding the need to curtail, or waste, renewable energy.

Demand response is already a sizable resource in the United States, with nearly 10 million customers enrolled in demand response programs, and 11.8 GW successfully deployed in 2016 to reduce the annual system peak. Global demand response capacity is around 40 GW, but IEA estimated that greater digitalization could increase demand response capacity to 450 GW by 2040. One study estimates demand response could save $270 billion of avoided investment in new electricity generation capacity and transmission and distribution. In the European Union, digitally enabled demand response could reduce curtailment of solar by 45 TWh by 2040, both boosting its share of power generation and reducing CO_2 emissions.

Smart Manufacturing. Industrial facilities accounted for 38 % of global final energy consumption and 32 % of U.S. energy consumption in 2014, with U.S. manufacturers having spent about $200 billion annually on energy. More-efficient energy use can reduce costs for manufacturers, while also reducing the energy and environmental footprint of manufacturing.

"Smart manufacturing" (i.e., "digital manufacturing") refers to the integration of ICT in the manufacturing environment for real-time management of energy, productivity, and costs across factories and companies. ITIF has published numerous studies on digital manufacturing and the steps companies and policymakers can take to accelerate the adoption of smart manufacturing technologies. The benefits to companies and workers are wide ranging, including improved productivity, reduced factory equipment maintenance costs, reduced equipment downtime, extended machine life, less material and energy waste, more-reliable product quality, reduced worker injuries, and improved energy efficiency and environmental performance. This report highlights the potential energy and environmental benefits of smart manufacturing.

The value of digital manufacturing comes from equipping machines with sensors that collect and communicate data so those machines can be used more efficiently and productively – and so businesses will be equipped with needed information to facilitate better decision-making. A 2015 McKinsey Global Institute report, “The Internet of Things: Mapping the Value Beyond the Hype,” finds that the application of Internet-connected devices in a factory setting could result in energy savings of 10 to 20 %. The Smart Manufacturing Leadership Coalition estimated that integrating ICT into manufacturing could achieve a 25 % improvement in energy efficiency, 25 % reduction in consumer packaging, and 40 % reduction in water usage. ACEEE similarly found that smart tools and solutions could lead U.S. manufacturers to realize savings of $15 billion in annual electricity costs, and a 20 % reduction in average company energy demand, by 2035.

These projected savings are beginning to materialize. In the United States, improved process controls produced estimated energy savings of over $330 million in small and medium-sized manufacturers over the period of 1987 to 2015. DOE‘s Superior Energy Performance (SEP) program, which is a measurement and verification protocol for evaluating energy efficiency improvements, has demonstrated an average energy performance improvement of 12 % across 11 manufacturing plants.

Smart manufacturing is especially important for hard-to-abate industrial sectors such as cement, steel, and chemicals manufacturing, as it represents one of the few near-term opportunities to reduce the energy and environmental footprint of heavy industry.

Some success is already being made in the cement sector. Petuum, a tech company specializing in developing artificial intelligence/machine learning solutions for industry, developed an AI model for cement manufacturing that it claims can reduce energy inputs by 2 to 5 % and increase yields by 2 %, while also resulting in average CO_2 emissions reductions of about 28,000 metric tons (kt) of CO_2 per year per plant. Cement manufacturer Argos is partnering with the University of Louisville and the Clean Energy Smart Manufacturing Innovation Institute to integrate predictive models, data analytics, sensors, and machine learning into a system platform to reduce the energy intensity of clinker production, a key step in the cement manufacturing process. In 2019, Lafarge Holcim launched an initiative to combine “digital twins” with AI, automation, and robotics to improve operational efficiency by 15 to 20 %, enabling the company's 270 cement plants to reduce the carbon intensity of the cement they manufacture.

Similar opportunities for digital efficiency exist for steel and chemicals production, two other hard-to-abate sectors. Steel manufacturer ArcelorMittal installed variable frequency drives in its water pumps in a steel plant in Indiana to provide just the amount of water required for cooling the steel, saving the company an estimated $360K/yr in electricity costs at just the one plant. Other researchers are combining machine learning with generative design to develop buildings and infrastructure that use less cement and steel in the first place. In the chemicals industry, digitalization has the potential to reduce CO_2 emissions by 60 to 100 million metric tons by 2025 through improved efficiencies and fewer fuel inputs, according to analysis by the World Economic Forum. The Dow Chemical Company is partnering with the University of Delaware and DOE to develop an open-source software and data hub to accelerate modular chemical process intensification and improve energy efficiency of chemicals production.

Agriculture is a climate-dependent industry. Since many regional ecosystem characteristics are determined by climate, changes in agro-climatic elements, such as temperature, precipitation and sunlight, have an impact on agricultural ecosystems and arable and livestock production. Responsible for the bulk of food production in developing countries, smallholder farmers are particularly vulnerable to climate change. However, mobile-enabled tools are revolutionising the agricultural sector in LMICs, often combining services that can help farmers respond to climate-induced changes. The emergence of low-cost digital technologies has created an unprecedented opportunity for mass collection, aggregation and dissemination of information and data at the farm level. Although not originally designed for this purpose, "virtual sensing" allows weather data to be collected from smartphones, connected cars and commercial microwave links (CMLs) used in mobile networks to transmit signals.

Digital advisory tools delivered via mobile phones by mobile operators, NGOs, governments and tech companies, play an important role in the dissemination of skills and techniques for more efficient and sustainable production techniques, in promoting agri- conservation practices and supporting adaptation to climate change through lower water use. For example, reducing the unnecessary use of fertilisers can be accomplished by raising awareness and motivating farmers to use alternatives. Examples of digital advisory services include those delivered by mobile operators, such as Dialog's Govi Mithuru in Sri Lanka, Econet's EcoFarmer in Zimbabwe and Telenor Pakistan's Khusaal Zamindar. Climate adaptation can also be supported through better advisory services that can lead farmers to adopt climate-smart technologies and practices.Examplesinclude Ignitia's Iska product in West Africa, a 48-hour, highly localised weather forecast service delivered daily via SMS.

The growing availability of data and new technologies to make sense of data, such as AI, machine learning and big data analytics, are making it possible to provide farmers with customised information based on field-level conditions. For example, climate indicators that are linked to on-farm activities. To strengthen adaptation and food security across a broad base, digital advisory needs to be accurate, tailored to users and accessible. One such solution is Precision Agriculture for Development (PAD), which analyses satellite imagery together with soil data and a weather prediction model to provide customized advisory to farmers. Peer-to-peer and participatory advisory services are another way to tailor advice to farmers' needs. We farm, currently operating in Kenya, Tanzania and Uganda has built a farmer-to-farmer digital network powered by big data, AI and machine learning to enable peer-to-peer, crowdsourced knowledge.

Smart farming refers to the use of sensors, drones, satellites and other farm assets to generate and transmit data about a specific crop, animal or practice to support agricultural activities. Smart farming solutions often rely on connectivity between IoT-enabled devices to optimize production processes and growth conditions, while minimizing costs and saving resources. In addition to enabling better field monitoring and management, smart farming tools generate critical agricultural data to support farmers' decision making. Examples of smart farming solutions include remote equipment and operation monitoring, such as irrigation systems and smart greenhouses (e.g., Illuminum Greenhouses in Kenya), livestock and aquaculture management (e.g., Jala and eFishery's smart feeding solutions in Indonesia) and shared assets that enable farmers to access agricultural equipment on demand via mobile apps.

In the agricultural sector, there are promising opportunities for digital solutions in logistics and supply chain integration, such as agricultural e-commerce platforms. These solutions provide a more direct way for farmers to access urban markets and sell their produce, and helps to reduce food waste, a major contributor of GHG emissions. Reducing food waste in LMICs will depend greatly on better infrastructure, including roads and cold storage, as well as more integrated and reliable value chains. For example, Inspira Farms offers energy- efficient, small-scale cold storage and packhouses, asset financing and technical services to address the challenges of post-harvest losses and limited market access for small and growing agribusinesses. In a study funded by UK Aid, Inspira farms estimated that early cold-chain solutions have the potential to reduce post-harvest losses by 25 to 50 %.

Intelligent Transportation Systems. Transportation accounted for 69 % of petroleum use and 33 % of U.S. CO_2 emissions in 2018. The average U.S. household spends 16 % of its total family expenditures on transportation, making it the most expensive spending category after housing. ICT can make transportation systems smarter and more connected, enabling greater energy efficiencies while also saving consumers time on the road and fuel costs. ICT has multiple applications, including optimized route planning based on real-time traffic data; automated vehicle operation within transit agencies and freight logistics companies; and smart charging for electric vehicles (EVs).

Real-time traffic data and improved traffic management are already transforming cities and freeways, allowing drivers to respond to congestions and road conditions immediately. As of 2014, 63 % of freeway miles have been equipped with real-time traffic sensors, which feed into route planning and traffic apps such as

Google Maps and Waze, allowing drivers to choose optimal routes to reduce their time on the road. Time savings for drivers also translates into less city congestion, reduced fuel consumption, improved air quality, and less GHG emissions. Similarly, adaptive traffic signals can sense traffic levels at intersections and use signal timing to reduce city congestion, saving drivers time while also reducing idling, fuel consumption, and emissions. One study found that adaptive traffic signals in Hamburg, Germany, reduced CO_2 emissions by 8.5 % compared with “dumb” traffic signals that operate on fixed time intervals. More and more transit authorities are seeing the value of smart traffic signals. The number of U.S. transit agencies deploying smart signals doubled between 2010 and 2013.

Improving transportation efficiencies is especially important for harder-to-abate transportation modes such as shipping, trucking, and air travel. Integrating ICT with these sectors could provide near-term efficiency opportunities as low-carbon alternatives are being developed. For example, connected ships and ports could optimize port arrival timing, thereby reducing port congestion and improving air quality while also saving fuel.

Freight transport is another area wherein ICT applications can enable significant energy savings and emissions reductions. The 2018 “Mission Possible” report found that ICT-enabled route optimization based on real-time traffic data can save fuel by shifting operations to less-congested times and routes. Similarly, improved supply chain logistics and data sharing between companies could enable them to deliver more goods while reducing the number of trucks and amount of fuel used. Together, these two measures could yield energy savings of up to 15 %.

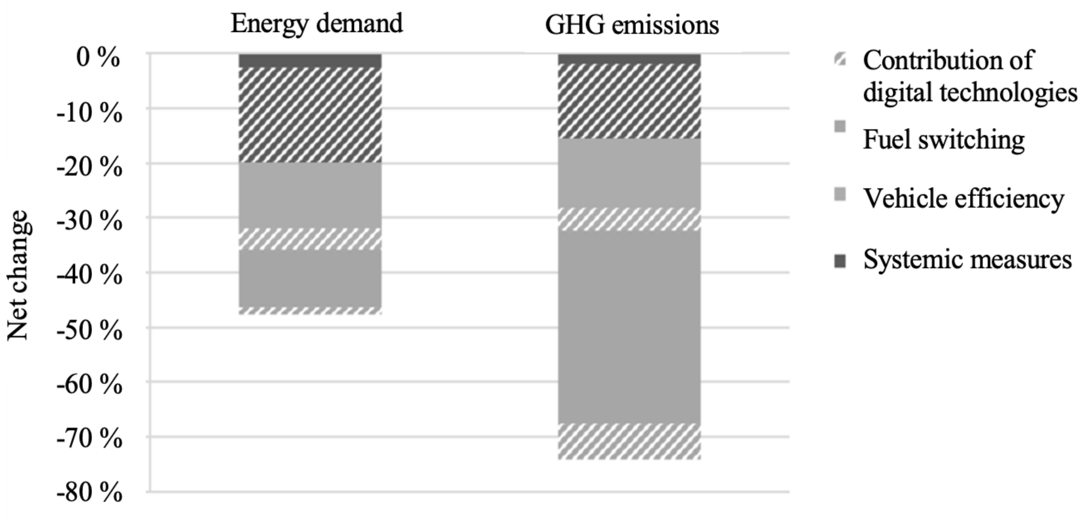


Figure 74. Digitalization’s impact on energy use and emissions reductions in freight trucking

Source: Colin Cunliff (2020) Beyond the Energy Techlash: The Real Climate Impacts of Information Technology https://itif.org/publications/2020/07/06/beyond-energy-techlash-real-climate-impacts-information-technology

Platooning trucks (i.e., shortening the gap between them in order to reduce aerodynamic drag) is an emerging option for decreasing fuel consumption, as are connected trucks using radar sensors and vehicle-to-vehicle communication to safely follow each other. Studies from DOE and ACEEE have shown fuel savings from platooning in the range of 10 to 17 %.

IEA's 2017 report "Future of Trucks" explores a broad range of decarbonization opportunities in the truck sector, including system measures (e.g., platooning and route optimization), improved vehicle efficiency (e.g., automatic tire pressure adjustment systems), and fuel switching to low-carbon fuels (including electricity). The study finds that digital technologies can make significant contributions to all three categories, with the largest potential emissions and energy savings coming from systemic measures (Figure 74). Among all three categories, digital technologies have the potential to reduce trucking energy demand by 23 %, and GHG emissions by 24 %, by 2050.

Similar digital approaches could help the aviation industry reduce its energy and carbon footprints. Real-time data from aircraft sensors can help pilots make in-flight decisions to reduce fuel use, while optimized route planning can increase system efficiencies. Airbus is exploring the use of "wake-energy retrieval" to reduce emissions from air travel. Similar to platooning for trucks, wake-energy retrieval enables a plane to fly in the wake of another in order to take advantage of the free lift and thereby reduce its fuel consumption. Wake-energy retrieval is the same tool a flock of geese flying in a "V" shape use to conserve energy. In a study of flights conducted in 2016, Airbus found that fuel savings of 5 to 10 % could be achieved when 2 aircraft fly 3 kilometers (about 2 miles) apart. However, air traffic management technology does not yet have the resolution to enable aircraft to fly so close together – and improvements in real-time flight tracking are needed for this approach to become viable.

Smart charging of EVs is a growing area of focus that can enable better vehicle-to-grid integration. With 8.5 million of them on the road in 2020, EVs account for less than 1 percent of the global vehicle fleet. But as costs come down, EVs are projected to capture a growing share of new sales. Bloomberg New Energy Finance projects the number of EVs will grow to 500 million by 2040, requiring new vehicle charging infrastructure and greater electricity generation capacity. If left unmanaged, people plugging their EVs into the grid to recharge at the end of each day could drive up peak electricity demand, resulting in greater buildout of electricity generation capacity and transmission infrastructure. Smart charging stations can shift charging times to later in the night when electricity demand is lower, while still meeting EV owners' needs to have their vehicles fully charged. Smart charging technologies can also enable EVs to provide grid services such as energy storage, demand response, and frequency support, potentially supplying EV owners with new streams of revenue as they support grid operations.

The value proposition for smart charging is large. IEA found that 500 million EVs on the road in 2040 would require up to 300 GW of new electricity-generating capacity, but smart charging could reduce that to 190 GW, thereby saving $280 billion of investment in new electricity generation capacity and transmission infrastructure. Even if EVs grow to only 150 million – about 10 % of the global fleet

– the flexibility provided by smart charging could still avoid 65 GW of electricity capacity, saving $100 billion in investment.

Summarizing the above, digital technology can reduce emissions at scale and ideas on what can we do to stop climate change. Here are several ways:

1) Visibility: digital tools help us see and measure what we can't capture with a naked eye.

Climate change is the energy problem: 80% of all carbon emissions are linked to energy. However, a quarter of all emissions are created by the energy that is lost or wasted. Reducing (or eradicating) energy loss and waste can be done today and achieves significant reductions in emissions without requiring wholesale changes to our lifestyles.

Digital technologies enable us to monitor our homes, offices, and industries' performance and energy efficiency appliance by appliance and room by room.

2) Efficiency: what can be measured, can be improved and optimized.

Once our homes, workplaces, cities and industries undergo a digital retrofit – which can be done up to 10 times faster and more efficiently than physical insulation – the identified energy waste and CO_2 emissions can be eliminated. Overall, a whopping two-thirds of efficiency potential is untapped regarding energy savings: 82% in buildings, 58% in industry and 79% in infrastructure.

Digital provides the tools to automatically switch devices, lights, heating on and off as needed. Identify equipment that might be burning more energy than expected and investigate why. And optimize and automate our increasingly complex environments. In short, it gives us the data and tools to tackle the efficiency challenge.

Not only that, but using digital software solutions, energy efficiency can be prioritized and programmed in at the planning stage of a project. Even such energy-intensive processes as oil and gas production can achieve significant reductions in emissions with better planning and the deployment of digital solutions. A recent study we have undertaken with McDermott and io Consulting has found a staggering 76% reduction in operational emissions of oil and gas facilities could be achieved with a minimal total expenditure increase of 2%. This could be delivered through a mix of digital, renewable grid power, SF6-free switchgear, and certain modifications that would allow the facilities to eliminate the so-called fugitive emissions while encouraging remote operations and promoting staff safety.

3) Interoperability: designed to benefit people and the planet.

If we look at building processes and operations across homes, buildings and industry today – we'll see that they are fragmented and disconnected due to regional standards and proprietary systems. Open-standard yet cyber-secure software systems and tech partnerships enable us to surpass today's disconnected analogue-based workflows to claim full sustainability benefits.

Interoperable solutions will help reduce error and create a system of complete visibility from design to operations level, especially where on or offsite collaboration is a given across a number of critical segments, including the building stock, the grid, transportation and key infrastructure projects. Connecting all elements within buildings, which account for 40% of carbon emissions, would help solve one of the great challenges of our time – building efficiency.

4) Enablement: deploying and managing the transition to renewables.

The move to renewable energy and an increasingly electric world requires a more sophisticated and complex bi-directional smart power grid. Existing power grids have been built to support energy distribution from a relatively small number of energy producers to our workplaces, homes, public spaces, transport networks and infrastructure. And our energy consumption patterns have been highly predictable, down to energy surges during ad breaks on TV. As renewables replace fossil fuels, the production of energy starts to change hands. In addition to the large energy producers, businesses and individuals generate their own energy and sell it back to the grid. Our usage patterns are changing with the move to electric vehicles, electric heat pumps and streaming services. And we are consuming more electricity than ever.

Digital technologies are essential to create the next generation smart grid and support the integration and management of solar panels, EV charging and heating into our homes and workplaces.

5) Innovation: increased sustainable investment delivers impact at scale.

Not so long ago, large scale sustainability projects attracted specialist investors. Today, ESG investing is going mainstream. Money invested in ESG funds more than doubled in a year, as funds captured $51.1 billion of net new money in 2020. Whilst projects seeking to create new biofuels, battery technology, or mass-produce green hydrogen are costly, high-risk. They will take years to show returns, and digital environmental solutions are easier to understand, evaluate and monetize. They offer shorter investment cycles, faster ROI and provide more opportunities for investors to scale quickly. Of course, sustainable investing is not immune to “social” risk, but digital solutions offer versatility. Modern smart offices technologies help ensure appropriate capacity, occupancy and social distancing – all while effectively managing the building’s energy needs and air quality in the process. When sustainability tech innovations become capable of addressing public health, investors take notice, and innovation cycles have the funds to accelerate.

With the rapidly advancing digital technologies, we can accelerate progress to meeting global climate change commitments with tools at our disposal today. Moreover, there is no time to waste. Governments, businesses and societies have shown great agility to prioritize public health. Now we need to apply the same urgency when it comes to the health of our planet. Digital provides a step-change in how we approach, deliver and scale our sustainability efforts. A net-zero carbon future is undoubtedly green, but it must also be digital and electric.

REFERENCES

1. Glenn D. Rudebusch. Climate Change and the Federal Reserve. FRBSF Economic Letter. 2019-09. March 25, 2019. https://www.frbsf.org/economic-research/files/el2019-09.pdf.

2. World Population Prospects 2019, United Nations Organisation. https://population.un.org/wpp/Download/Standard/Population/.

3. Climate Chance & Security. Strengthening Resilience to Climate-Fragility Risks. UN Environment Assembly and Governing Council, 2021. https://www.unep.org/explore-topics/disasters-conflicts

4. World economy set to lose up to 18% GDP from climate change if no action taken, reveals Swiss Re Institute's stress-test analysis. Swiss Re Group. https://www.swissre.com/dam/jcr:b257cfe9-68e8-4116-b232-a87949982f7c/nr20210421-ecc-publication-en.pdf.

5. Harris, Jonathan & Roach, Brian. (2017). Environmental and Natural Resource Economics: A Contemporary Approach. 10.4324/9781315620190

6. Harris, Jonathan & Codur, Anne-Marie. (2012). Economics of climate change. https://www.researchgate.net/publication/277305537_Economics_of_climate_change.

7. Keith Wade, Marcus Jennings. The impact of climate change on the global economy. Schroder Investment Management North America Inc. https://www.schroders.com/de/SysGlobalAssets/digital/us/pdfs/the-impact-of-climate-change.pdf.

8. Mendelsohn, Robert. 2009. Climate Change and Economic Growth. Commission on Growth and Development Working Paper; No. 60. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/28000 License: CC BY 3.0 IGO.

9. Stern, N. (2006). "Stern Review on The Economics of Climate Change (pre-publication edition). Part II Impacts of Climate Change on Growth and Development". HM Treasury, London. Archived from the original on 31 January 2010. Retrieved 31 January 2010. https://webarchive.nationalarchives.gov.uk/ukgwa/20100407173011mp_/http://www.hm-treasury.gov.uk/d/Part_II_Introduction_group.pdf.

10. Covington, Howard and Thamotheram, Raj, The Case for Forceful Stewardship (Part 1): The Financial Risk from Global Warming (January 19, 2015). Available at SSRN: https://ssrn.com/abstract=2551478 or http://dx.doi.org/10.2139/ssrn.2551478.

11. Nordhaus, William. *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. Yale University Press, 2013, http://www.jstor.org/stable/j.ctt5vkrpp

12. *Martin Weitzman*, (2012), GHG Targets as Insurance Against Catastrophic Climate Damages, *Journal of Public Economic Theory*, **14**, (2), 221-244 https://scholar.harvard.edu/files/weitzman/files/ghgtargetsinsuranceagainst.pdf.

13. Pearce.D.W, Cline.W.R, Achanta.A.N, Fankhauser.S, Pachauri.R.K, Tol.R.S.J. and Vellinga.P (1996), "The Social Costs of Climate Change: Greenhouse Damage and the Benefits of Control", In Bruce, J.P., Lee, H. and

Haites, E.F., (Eds.) (eds.) Climate Change 1995: Economic and Social Dimensions, Cambridge University Press, Cambridge.

14. Simon Dietz, Nicholas Stern, Endogenous Growth, Convexity of Damage and Climate Risk: How Nordhaus' Framework Supports Deep Cuts in Carbon Emissions, *The Economic Journal*, Volume 125, Issue 583, March 2015, Pages 574–620, https://doi.org/10.1111/ecoj.12188.

15. Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times. The 2018 Report of the Global Commission on the Economy and Climate. https://newclimateeconomy.report/2018/wp-content/uploads/sites/6/2019/04/NCE_2018Report_Full_FINAL.pdf.

16. How is climate change affecting the economy and society? Iberdrola, SA. 2021. https://www.iberdrola.com/environment/impacts-of-climate-change.

17. Gerard George, Ryan K. Merrill, Simon J. D. Schillebeeckx (January 23, 2020) Digital Sustainability and Entrepreneurship: How digital innovations are helping tackle climate change and sustainable development https://doi.org/10.1177/1042258719899425.

18. Howard-Grenville, J., Buckle, S. J., Hoskins, B. J., George, G. (2014). Climate change and management. Academy of Management Journal, 57(3), 615–623. doi:10.5465/amj.2014.4003.

19. William J Ripple, Christopher Wolf, Thomas M Newsome, Jillian W Gregg, Timothy M Lenton, Ignacio Palomo, Jasper A J Eikelboom, Beverly E Law, Saleemul Huq, Philip B Duffy, Johan Rockström, World Scientists' Warning of a Climate Emergency 2021, BioScience, Volume 71, Issue 9, September 2021, Pages 894–898, https://doi.org/10.1093/biosci/biab079.

20. Embry, E., Jones, J., York, J. (2019). Climate change and entrepreneurship. In George, G., Baker, T., Tracey, P., Joshi, H. (Eds.), Handbook of inclusive innovation: The role of organizations, markets, and communities in social innovation (pp. 377–393). Edward Elgar.

21. James, H., Janie, R., Stephen, T. (2018). Urgent action to combat climate change and its impacts (SDG 13): Transforming agriculture and food systems. Current Opinion in Environmental Sustainability, 34, 13–20.

22. Delmas, M. A., Lyon, T. P., Maxwell, J. W. (2019). Understanding the role of the Corporation in sustainability transitions. Organization & Environment, 32(2), 87–97.doi:10.1177/1086026619848255.

23. Nave, A., Ferreira, J. (2019). Corporate social responsibility strategies: Past research and future challenges. Corporate Social Responsibility and Environmental Management, 26(4), 885–901.doi:10.1002/csr.1729.

24. York, J. G., Vedula, S., Lenox, M. J. (2018). It's not easy building green: The impact of public policy, private actors, and regional logics on voluntary standards adoption. Academy of Management Journal, 61(4), 1492–1523.doi:10.5465/amj.2015.0769.

25. PwC . (2017). Sizing the prize: What's the real value of AI for your business and how can you capitalise?

https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf.

26. Jarrahi, M. H . (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. Business Horizons, 61(4), 577–586. doi:10.1016/j.bushor.2018.03.007.

27. Pasolini, G., Buratti, C., Feltrin, L., Zabini, F., De Castro, C., Verdone, R., Andrisano, O et al. (2018). Smart city pilot projects using LoRa and IEEE802.15.4 technologies. Sensors, 18(4), 1118.doi:10.3390/s18041118.

28. Hammi, M. T., Hammi, B., Bellot, P., Serhrouchni, A. (2018). Bubbles of trust: A decentralized blockchain-based authentication system for IoT. Computers & Security, 78, 126–142. doi:10.1016/j.cose.2018.06.004.

29. Antonopoulos, A . (2015). Bitcoin: Dumb networks, innovation, and the Festival of the commons. O’Reilly Radar Summit. https://www.youtube.com/watch?v=x8FCRZ0BUCw.

30. Pizhuk, O. (2019). The key drivers of digital transformation of the economy. Bulletin of the Kyiv National University of Technologies and Design. Series: Economic sciences, 135 (3), p. 38-47.

31. Bitkom (2021), The digital economy’s impact on the climate, https://www.bitkom.org/climate-protection; and “Digitization can save one in five tons of CO_2”, https://www.gsma.com/betterfuture/wp-content/uploads/2019-/12/GSMA_Enablement_Effect.

32. GSMA (2021), “The Role of Digital and Mobile-Enabled Solutions in Addressing Climate Change”, www.gsma.com/mobilefordevelopment.

33. Colin Cunliff (2020) Beyond the Energy Techlash: The Real Climate Impacts of Information Technology https://itif.org/publications/2020/07/06/beyond-energy-techlash-real-climate-impacts-information-technology.

34. “Innovations in Sensors and Controls for Building Energy Management” (DOE Building Technologies Office, 2020), https://www1.eere.energy.gov/buildings/pdfs/75601.pdf.

35. ITIF adaptation of IEA, Cumulative energy savings in buildings from widespread digitalisation in selected countries, 2017–2040, IEA, Paris, https://www.iea.org/data-and-statistics/charts/cumulative-energy-savings-in-buildings-from-widespread-digitalisation-in-selected-countries-2017-2040.

VII. FEATURES OF THE IMPLEMENTATION OF DIGITAL TECHNOLOGIES IN ECOTOURISM

7.1. Digital services in ecotourism

Hanna Zhosan
PhD (Economics),
Associate Professor
of Department of Management and Information Technology
Kherson State Agrarian and Economic University
E-mail: enn89@ukr.net
ORCID ID 0000-0002-3577-6701

Liudmyla Aleshchenko
Assistant of Department of Management and Information Technology
Kherson State Agrarian and Economic University
E-mail: 20liudmila2017@gmail.com
ORCID ID 0000-0002-7119-2922

Previously, tourists could be easily recognized by maps and guidebooks in hand. Today, travelers are given the habit of constantly using a smartphone or laptop - a modern traveler obtains all the necessary information on the Web. The Internet makes it possible not only to find out which places are worth visiting in a certain city, but also to find an accommodation for yourself, buy plane tickets and much more. Today, special online services for tourists have a lot of useful functions - tourism has adopted digital and makes money on it.

Digital travel services such as Booking, Airbnb or Aviasales have been around since the early 2000s. These services are online booking and ticket purchasing systems. Today it is no longer possible to imagine traveling without the use of such platforms. According to Google statistics, today's tourists, when planning their trip, make about 400 searches. This sequence is used by travel companies usually in order to influence the decision of the tourist and persuade him in favor of a certain company, route or hotel.

Ecotourism includes travel related to the satisfaction of amateur, professional and scientific interests, training and education. It can include such types of tourism as religious, ethnic and health-improving. Consequently, the objects of ecological tourism can be both natural and historical and cultural monuments, specially protected territories and places of compact residence of peculiar ethnic groups of the population that have preserved their customs and traditions, which may be of interest to recreators from other regions and countries [8].

In the works of V.I. Prelovsky, the structure of the concept of "ecological tourism" is determined. The author, based on the analysis of domestic publications, identifies about 20 characteristics of ecotourism [Fig. 75], called alternative, adventure, responsible, environmental, green, sustainable, supportive, sparing, mild, rural, agrarian, rural (farming), forest, biosphere, scientific, etc. [8]. As you can see, the range of epithets in relation to ecological tourism is extremely diverse.

All these forms of tourism and the terms used to designate them in one way or another owe their origin and development to the powerful impact on modern society of the ecological imperative, as well as to the concepts of sustainable or, more precisely, supporting the development and conservation of biological diversity [2-10].

Figure. 75. The structure of the concept of "ecological tourism"
Source: Systematized by the authors

The World Trade Organization gives the following definition of ecotourism: “ecological tourism is tourism to untouched corners of nature”. But, according to N. N. Mamaeva, this definition is very broad and includes a number of other areas of tourism. More perfect is the definition of the US ecotourism society, the International Union for Conservation of Nature: “ecotourism is any type of tourism and recreation in nature that does not damage natural complexes, contribute to the protection of nature and improve the welfare of the local population” [9].

As for environmental professionals, they prefer to use the following definition: “ecotourism is a type of nature tourism, the main purpose of which is environmental education of tourists, provided that the impact on natural complexes is minimal”. Therefore, it is necessary to define ecological tourism as an activity based on the following principles:

⇒ A trip to nature, and the main content of such trips is acquaintance with wildlife, as well as with local customs and culture.

⇒ Minimizing negative environmental and socio-cultural consequences, maintaining environmental sustainability.

⇒ Promotion of nature conservation and local socio-cultural environment.

⇒ Environmental education and awareness.

⇒ Participation of local residents and their receipt of income from tourism activities, which creates economic incentives for them to protect nature.

⇒ Economic efficiency and contribution to sustainable development of the visited regions [6, 5].

A common flaw in all of the above definitions is the loss of the most important component of ecotourism activities - environmental education and the formation of environmental awareness. N. N. Mamaeva offers the following definition of ecological tourism: “ecological tourism is a kind of nature tourism, which, as a rule, is carried out in relatively untouched corners of nature for the purpose of environmental education, acquaintance with the traditional way of life, crafts, folklore traditions and the historical past. The main conditions for ecological tourism are the sustainable use of natural resources, ensuring the preservation of the natural and cultural complex and supporting the local, mainly traditional economy”[3].

The concept of ecotourism can be presented in the form of the following basic principles:

1. Principle of minimizing negative impact: natural and socio-cultural compatibility as a fundamental condition; supervision and participation by local communities; equitable access to natural resources; compliance with the maximum permissible recreational loads.

2. Principle of strengthening and wide coverage: creating financial, economic and socio-cultural benefits for protected areas and local populations.

3. The principle of enhancing environmental, ecological and cultural awareness, including environmental education, respect for customs and traditional way of life of local communities, exchange of experience [1].

According to A.V. Drozdov, the following functions of ecotourism can be distinguished:

⇒ enrichment of tourists with vital general cultural and natural-scientific environmental knowledge, including in the field of personal and public environmental safety;

⇒ emotional recovery, getting rid of "city" stress;

⇒ socialization of the world outlook of tourists through the formation of their ecological culture, including new value orientations and behavior that are important for the sustainable development of society, and are adequate to the ecological imperative;

⇒ the formation of a tolerant attitude towards previously unknown cultures and ethnic groups, towards their way of life and traditions, adapted to the natural environment;

⇒ creation of new jobs for the local population;

⇒ stimulation of traditional forms of nature management, production of ecologically clean food products;

⇒ increasing investments both in infrastructure and services, and in nature protection;

⇒ the growth of the welfare of the local population and the development of special education aimed at acquiring tourism and nature conservation professions;

⇒ development of crafts;

⇒ development of local self-government [2].

The above definitions, principles and main features of ecotourism show that it is advisable to distinguish between two interpretations of ecotourism - narrow (classical) and broad. It is interesting to note that a narrow interpretation of ecotourism prevails in countries with vast territories such as Canada, the USA, and Australia. This interpretation is supported and developed, first of all, by representatives of the "green" movement. The broad interpretation is held by tourism experts and its researchers from Western European countries with very limited resources of “wild nature”.

The greening of public consciousness and behavior and, in particular, ecological tourism have recently had a significant impact on the harsh forms of tourism. Now, many tourists during their holidays willingly combine two and three-week "beach" programs with short purely ecological excursions. Although they prefer a very comfortable vacation, but in environmentally friendly conditions, they encourage hotel owners and resort authorities to take care of environmental protection and introduce eco-friendly technologies into the tourism industry.

Therefore, along with the actual ecological tourism, one can also single out eco-technology tourism, which has already been repeatedly noted in his works by A.V. Drozdov. This direction in the development of the tourism industry must certainly be in our field of vision. Moreover, ecological technologies are equally necessary for purely ecological tours and for tourism in general.

All the variety of types of ecotourism should be divided into two main types:

1) ecotourism within the boundaries of specially protected natural areas (water areas) - the development and implementation of such tours is a classic direction in ecotourism, and the corresponding tours refer to ecotours in the narrow sense of this term, they can be attributed to the "Australian" model of ecotourism;

2) ecotourism outside the boundaries of specially protected natural areas (water areas) - a very wide range of types of ecologically oriented tourism can be attributed to this type of tours, from agritourism to a cruise on a comfortable liner. This group of ecotours can be attributed to the "German" or "Western European" model [2].

Like other groups of tours, ecological tours can be classified according to many characteristics, however, two generic characteristics should be considered the most significant:

a) the main purpose of the tour - on this basis, it is advisable to distinguish between the following types of ecotours: observation and study of "wild" or "cultivated" nature with training in environmental knowledge; rest surrounded by nature with emotional, aesthetic goals; treatment with natural factors; sports and adventure goals;

b) the main object that determines the content of the tour program and partly the form of its organization. On this basis, the following types of ecotours are distinguished: botanical, zoological, geological tours; speleological, water, mountain tours; ecological-ethnographic or archaeological, ecological-cultural tours; agroecotours [2].

Of course, the goals of the tour and its objects are interconnected, and both main generic characteristics cannot be considered absolutely independent grounds for classification (in the real program of the tour, its goals and objects are often combined and combined). Nevertheless, each organizer and participant of the tour can determine its main features and attribute each specific tour to one or another type.

Volgograd specialist L.V.Detochenko suggests distinguishing three main directions of ecological tourism:

1. Classic natural ecotourism, the main object of which is wild nature, which practically does not experience anthropogenic impact.

2. Recreational ecotourism, the main object of which are territories modified by man, territories with a secondary quasi-nature, but relatively ecologically favorable for the purposes of recreation and tourism.

3. Socio-cultural ecotourism, the essence of which is acquaintance and study (but without any interference) by tourists of culture, customs, lifestyle, beliefs, peculiarities of interaction with the environment of various peoples inhabiting a particular territory [18].

So, ecotourism is a developing direction in the tourism industry, it is not always understood in the same way in different countries, its forms are dynamic, it penetrates into areas of tourist activity that were previously far from ecological orientation and it is hardly reasonable to limit it to too strict framework and one single correct definition. Ecotourism, if properly organized, can bring significant income to the state budget, and if it is successfully developed, it can play its role in resolving the modern socio-ecological crisis.

Currently, as part of the development of Internet technologies and telecommunications networks, there is a tendency to increase people's interest in travel Internet services, which allow online and without leaving home to purchase travel products. Such products that allow you to plan your trip quickly and comfortably include: booking and buying air tickets, hotel rooms, booking excursions or complex travel products, tours, cruises, etc. The digitalization of the travel industry in the future will inevitably occur due to the desire of customers to reduce the number of "touches", the increasing use of digital technologies in everyday life, as well as the digital habits of a new generation of tourists. At the same time, experts assess the prospects of digital startups in the industry somewhat restrainedly, as well as the gamification of travel products.

Experts also associate lists of professions with the upcoming digitalization of the industry, which will significantly change or even die out in the interval of 5-10 years. Thus, more than half of the respondents believe that the travel agency business will undergo the greatest transformation, which is increasingly being replaced by aggregators of tourism products. Alternative options may include:

⇒ changing the functionality of museum staff;
⇒ transformation of the role of tour guides;
⇒ transformation of the tour operator business.

As for the personnel directly involved in the hotel business, the first place may be the transformation of the functionality of the middle management level, then the line personnel, the change in the work of animators, the transformation of the work of housekeeping services. If we talk about what kind of specialists are missing in the industry now, then this list looks like this:

⇒ guides, tour guides;
⇒ line, service personnel;
⇒ managers, top managers;
⇒ IT specialists;
⇒ marketers, promotion and branding specialists.

Tourism is currently a dynamically developing sector of the economy, which also causes increased attention to the processes of its development. At the same time, in the modern conditions of the development of the tourism industry, in the age of developing technologies and the Internet, the demand for the development of the online tourism industry is growing, the culture of customers using bank cards and electronic systems, online shopping and Internet services is growing.

Internet services in ecotourism are specialized sites that provide services for self-planning and travel organization, which greatly facilitates work and saves time. The Internet service necessarily includes a site filled with Internet technologies. The technology stack of travel Internet services includes: programming languages, frameworks, databases, operating systems, a communication system, integration with various services (CRM, 1C, SMS mailing, push notifications). The concepts of "Internet service", "Internet technologies" and "site" are continuously interconnected with each other and form a single product in the form of a separate laconic service with the main function. Let's take a closer look:

⇒ Internet services in tourism are separate resources that solve certain tasks related to organizing and planning a trip;

⇒ Internet technologies are technologies for creating and maintaining information resources (sites, blogs, chats, etc.);

⇒ A site is a web page united by a single theme.

The services offered by travel agencies via the Internet vary. Typically, most travel agencies offer online services that can be fully automated (e.g. search services for tourist products). Of course there are some travel agencies that do not provide any online service. These support their existence on the Internet for purely advertising purposes (Roger-Monzó et al., 2015). The tourist services currently offered by the various travel agencies are grouped into three categories (Table 44):

⇒ Tourist information search services

⇒ Booking services
⇒ System management services

Table 44.

Basic services of an online travel agency

Search services	**Booking services**	**System management services**
Search for tourist products: - Travel packages - Hotels - Means of transport - Cruises - Tickets (air, boat, etc.)	Booking of tourist products through: - Special booking forms (online or in a conventional way) - Direct communication with the travel agency via e-mail.	These services are optional and concern the travel agency: - Online introduction of tourist information - Updates - Collection of statistics - Immediate customer service with automated notification on the course of their booking information etc.

Source:: Xiang, Magnini and Fesenmaier, 2015

In their majority, existing travel agencies on the Internet offer both tourist search services and booking services. But few are the travel agencies that offer dynamic search or online booking services. Technological developments and the needs of the consumers (fast and correct service, direct search results) impose the use of the newest application development techniques (use of a database for the dynamic extraction of information, the ability to make a booking online, etc.)

For a fuller understanding of the functions of an online travel agency, it is necessary to examine the actors involved in all phases of operation. In order to make a trip through an online travel agency, the involvement of three actors is necessary (Lin, 2016):

⇒ Providers of basic tourist services
⇒ Customers
⇒ Intermediaries (travel agencies)

This categorization requires the creation of three different subsystems that will serve the needs of each actor. The role of these actors is the same as the role they play in their offline commercial transactions. The provider of basic tourist products and services sells and promotes its products to the customer/consumer. The customers are looking for the products they want and then, if they want, they buy them. The intermediaries, i.e. the travel agency, are those that undertake to bridge the gap between the providers and the final customers. An analysis of the services offered is presented in the following for each subsystem.

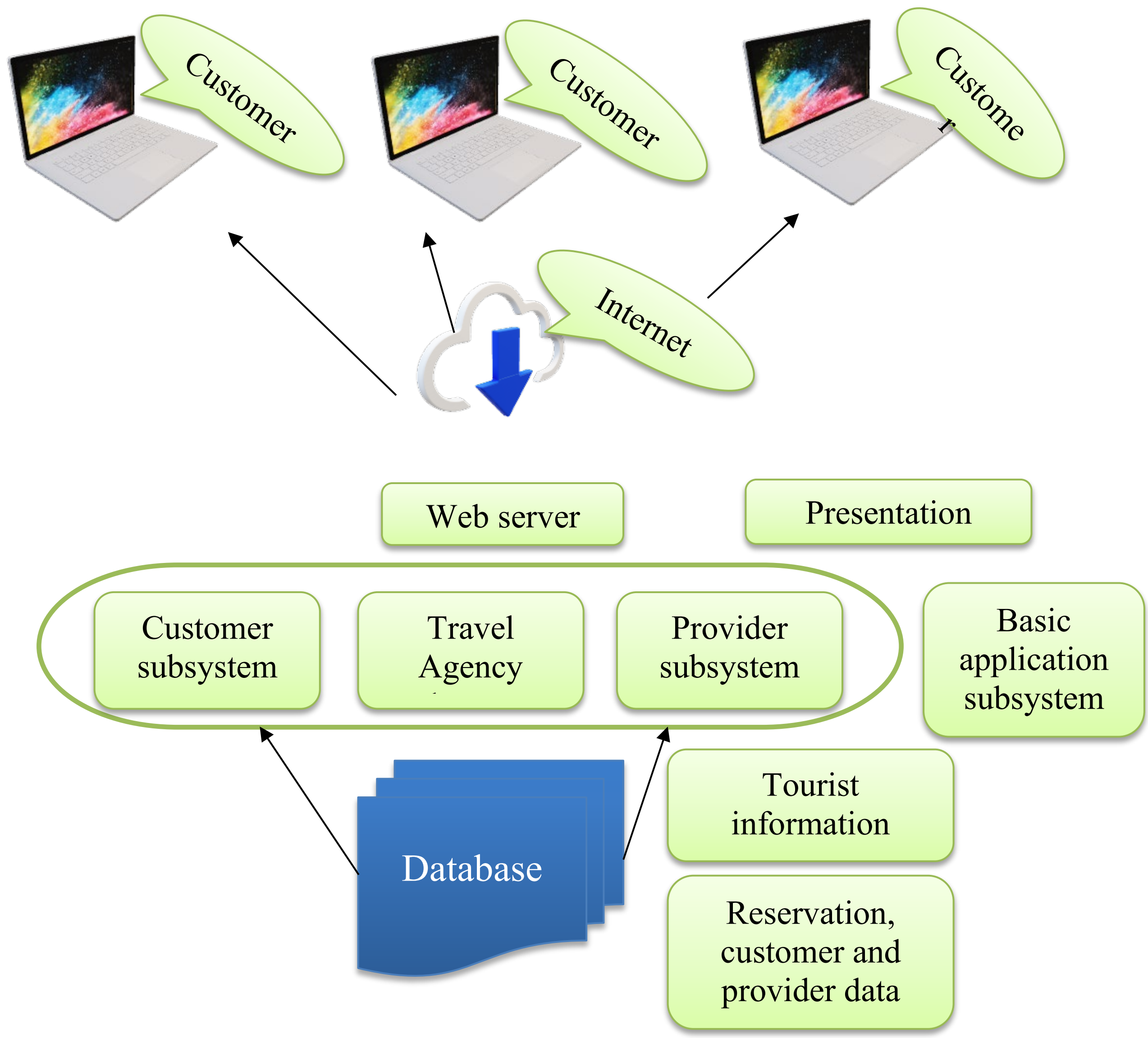


Figure. 76. Standard system of an online travel agency
Source: Systematized by the authors

As can be seen from the architecture in the following Figure 76 (Ling et al., 2015), in order for an online travel agency system to support the above functions, it should be composed of three basic levels plus some interaction characteristics in terms of the booking service. This point entails the difficulty of the system, as bookings relating to providers of basic tourism services such as hotels, airlines, etc., should be passed on from consumers to providers via the travel agency. The problems that arise relate to proper synchronization, efficient booking management, availability check, etc.

The basic subsystems discussed above can be implemented with an integrated e-Commerce application development environment. However, there is a set of basic technologies that are necessary for the implementation of an online travel agency system, such as:

⇒ Web Server. It is a basic subsystem to derive tourist information registered in the online database. For this purpose, it is necessary to interconnect with the subsystem level and thus the database for dynamic information

⇒ Web Forms. As with the electronic publishing system, the use of Web Forms is necessary for the development of electronic forms (e.g. search, registration, booking forms, etc.). In addition, the Secure Sockets Layer technology combined with Java can also be used to securely transfer data between customers and the travel agency. Through the Web Forms technology, the interface between the providers of tourism services and the travel agency can be implemented. In particular, providers will be able to update the system via e-forms, and also to monitor the reservations, customers etc.

⇒ XML / EDI. For the automated communication between the travel agency and the providers of basic tourism services, the XML/EDI technology can also be used to exchange documents and process transactions

⇒ Multimedia Database. All tourist information will be registered in the database, in a multimedia format (image, audio and video) so that the final consumer has a full picture and information on the tourist products. Also the database will include information so that the final consumer has a complete picture and information about the tourist products. The database will also include information about both providers and customers. Reservations, which are one of the most basic information, will also be registered in the database.

⇒ Payment Subsystem. In this case, payment between consumers and the travel agency may be concluded via credit cards or electronic money payment systems. To this end, there must be the necessary infrastructure both in the agency and in the bank conducting the banking transactions.

⇒ Data Mining OLAP. These technologies can be used to analyze the data collected by the system (mainly customer and booking information). In this way, the agency can analyze the purchasing behavior of its customers and proceed with projections, renewal of its products and offers, etc.

Analysis of a number of information sources (Monakhov, Fomina, 2019; Morozova, 2019; Polhova, 2015; Yakovleva, 2020) allows us to highlight some of the features of travel Internet services, allowing them to give a more complete description.

1. The prevalence of mixed types of services over highly specialized. For example, Booking is a service for booking hotels, but in addition, another important function is the ability to book flights, as well as view the necessary information about the region, transfer, read reviews and see the rating.

2. Dominance of shopping services (marketplaces) over related services. For example, the Couchsurfing housing search service works according to the C2C marketplace scheme and builds a community of interests.

3. Ability to operate services in different modes (online / offline). Depending on the mode of operation, there are online services and offline services. For example,

the Galileo service containing vector maps can also work offline, which is very convenient if the device is not connected to the Internet.

4. Targeting a different target audience. Travel Internet services are aimed at tourists, travel companies and government agencies.

5. The content of the main functionality of the service is related to the provision of information. The main function is to provide the necessary information in the field of tourism, the ability to make a reservation: hotel, airline tickets, cars, train tickets, excursions, etc.

Also, travel services differ from other sites in brevity and minimalism in everything, including the main function. The priority direction in the field of online travel services is the creation and maintenance of interactive sites for the sale of tours, which is supported by interactive customer support online.

The authors consider the classification system of Internet services in tourism as a system for the distribution of objects of tourist services by classes in accordance with certain criteria. This classification assumes a qualitative grouping procedure aimed at highlighting certain properties. The basis of these groupings is made by many existing travel Internet services that act as objects of classification.

After assessing the advantages and disadvantages of various classification methods, as well as correlating the initial data on the objects of classification with the task at hand, the authors defined a hierarchical method with high information saturation and visibility as a method for classifying Internet services in tourism. The chosen method makes it possible to distinguish several levels (steps, tiers) of Internet services in accordance with their characteristic classification feature, which can be divided into classes and subclasses, which determines the depth of the classification system as a whole.

Depending on the source of funding, Internet services in tourism can be divided into commercial, non-commercial and crowdfunding. Most of the services are commercial, with a developed affiliate program. These services include: Onlinetours, GoAsia, HopaYacht. Non-commercial include such as Kayak, Flightradar. A fairly rare source of funding is crowdfunding, which includes the collective cooperation of people who voluntarily pool their money. The most common and popular service in this category is Couchsurfing.

Depending on the subject of interaction, travel Internet services can be divided into classes:

⇒ B2B (trade relations between legal entities and companies);

⇒ B2C (any business where the goods are received by the final consumer);

⇒ C2C (relations between individuals);

⇒ G2B (public services for business).

For example, services using B2B sales include: Sputnik8, Kassir. The most common business model, B2C, includes a commercial relationship scheme. As an example, the following services are: Airbnb, Tourex, Dreamlines. There are services that use an end-user-to-end e-commerce scheme in which the buyer and seller are not entrepreneurs in the legal sense of the word. Consider the example of the Couchsurfing service, which operates on a consumer-to-consumer basis. The members of the network provide each other with assistance and accommodation during the trip and organize joint trips. The next subject, G2B, includes various centers for business support, providing information on legal issues, and an electronic procurement system. For example, the services VisaToHome and Cherepacha are included in this class.

Summarizing the above, we can conclude that Internet services in tourism are divided into the following main groups:

1. Depending on the destination: shopping services and additional tourist services and related services.
2. Depending on the subject of interaction: B2B, B2C, C2C, G2B.
3. Depending on the channels and tools used for Internet marketing: social networks, blogs, chats, etc.
4. Depending on the device used: desktop or smartphone.
5. Depending on the mode of operation: online / offline.
6. Depending on funding sources: commercial, non-commercial and crowdfunding.

With the help of the selected features, Internet services are subdivided into levels, groups and classes in accordance with the name and classification of a certain indicator. Thus, by splitting services according to various characteristics and transforming them into certain classes, it becomes possible to develop a classification system for Internet services in tourism. Despite the variety of sites and services in the field of tourism that they provide, the most popular modern Internet services were divided by the authors into groups depending on a common feature, which made it possible to visualize the classification system.

The hierarchical structure of the classification of tourist Internet services is determined by the following levels: the name of the characteristics of the classification of Internet services is the zero level and is divided into classes depending on the selected classification characteristic; each subsequent class of the first level, in accordance with a certain characteristic (subject, type, etc.), is divided into subclasses that form the second level; each class of the second level is similarly divided into groups and forms subsequent levels. The analysis made it possible to single out the following main characteristics of the proposed classification system for Internet services in tourism (Table 45).

Table 45

The main characteristics of the classification system of modern Internet services in tourism

№	Description of characteristics	Meaning / Description
1.	Classification object (set element)	Internet services
2.	Classification method	Hierarchical
3.	The meaning of classification signs	Qualitative expression
4.	The number of common features (bases)	6
5.	Maximum number of levels (steps, tiers)	4
6.	Number of classification groupings	12

Source: Systematized by the authors

Table 46

Classification system for Internet services in tourism

Depending on the channels and online marketing tools used	Depending on the device used	Depending on the operating mode	Depending on funding sources	Depending on the subject of interaction	Depending on the destination	
					Shopping services for basic and additional travel services: air, railway, auto, moto / bike, water	Related services
Partnership programs	PC desk top	Offline services	Commercial	B2B services	Services for booking and purchasing transport services: in collective accommodation facilities, in the private sector	Information services: travel location information, helping travellers in emergencies
Loyalty programs	Mobile version of the site	Online services	Non-commercial	B2C services	Services for booking and purchasing accommodation services	Navigation services
Direct marketing (mailing / subscription)	Mobile app		Crowdfunding	G2C services	Online insurance services	Services of a complex of related services
Social network	Smartphone / Tablet			G2B services	Services for issuing visas	
Blogs					services for the purchase of organized tours and excursions	
Sites					Leisure services	
Chats					Services for the purchase of a set of basic and additional services	
Sai centers						

Source: Systematized by the authors

It should be noted that due to the hierarchical structure, the presented system of classification of Internet services in tourism, on the one hand, allows you to streamline the entire set of classification objects under consideration, and on the other hand, to observe the basic principle of classification, according to which each element of the set (one or another tourist Internet service) corresponds to a particular subset (included in a group / class / subclass). The study shows that Internet technologies have fundamentally changed business processes in tourism and customer behavior. Every year, more and more Internet services appear, designed for the convenience and improvement of many processes in the tourism sector. The popularity of the services continues to grow due to the expansion of the client base, which is reflected in the indicators of attendance and customer response. In the growth and development of the popularity of Internet services, one of the trends is a reduction in the time from the moment of booking services to a trip and an increase in the share of booking from smartphones. And since Internet services in tourism are an integral part of digital socialization, their popularity is associated with the comfortable opening of new prospects and opportunities.

7.2. The experience of countries in the digitalization of the tourism industry

Today, about 80% of tourists around the world plan their travels online. Turkey, for example, has announced that it is willing to invest heavily in digital marketing for its tourism industry. Sri Lanka announced the launch of a large-scale digital promo of the country as an attractive route for tourists. Indonesia has launched its own rental booking network in response to Airbnb's international expansion, with government support. Currently, the totality of types and directions of tourism, classified as ecological, has dozens of units. In particular, the majority of specialists distinguish such areas as green, adventure, nature-oriented, non-technical, biological, rural, agro-ecological, soft, recreational, health-improving and others [7]. And this list can be continued for a very long time. The reason for this is the lack of a clear definition and boundaries of ecotourism activities.

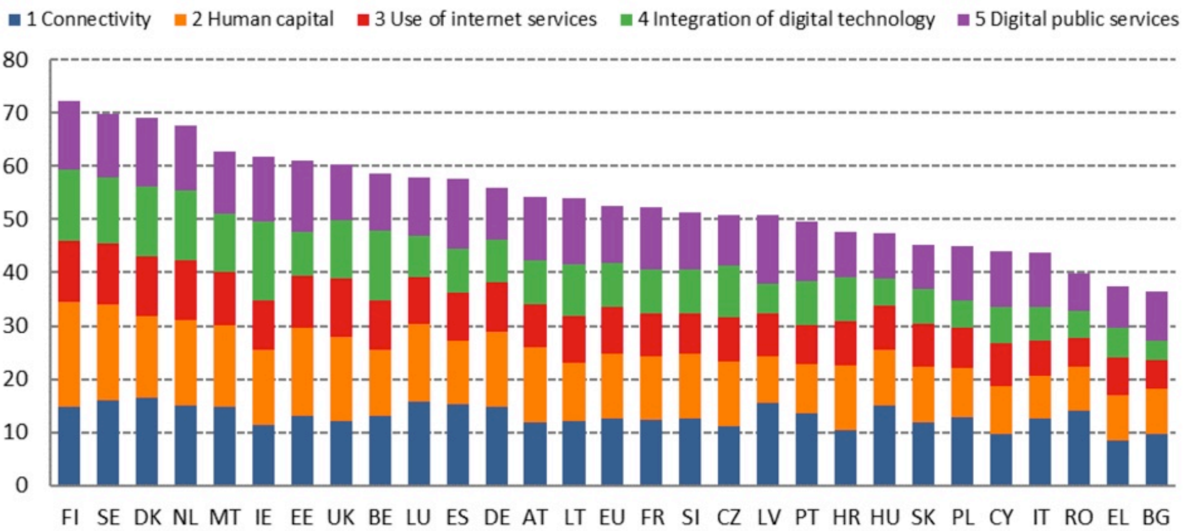


Figure 77. Digital Economy and Society Index, 2020
Source: Digital Economy and Society Index (DESI) 2020

Figure 3 shows the ranking of Member States on the Digital Economy and Society Index in 2020 based on 2019 data. Finland, Sweden, Denmark and the Netherlands have the most advanced digital economies in the EU followed by Malta, Ireland and Estonia. Bulgaria, Greece, Romania and Italy have the lowest scores on the index.

It is important to underline that the largest EU economies in terms of GDP are not among the digital frontrunners and this impacts on the overall performance of the single market. This being said, there are several initiatives that have recently been introduced in these Member States to improve the digitisation of the economy and society. Germany, which ranks 1st amongst EU countries regarding 5G readiness, has launched several measures with the aim of advancing digitisation and is driving initiatives in the area of IT security, supercomputing, artificial intelligence and blockchain. France has started a comprehensive effort to facilitate the digitisation of public services and businesses and to set up a dynamic ecosystem for tech start-ups. In December 2019, Italy adopted 'Italia 2025', a 5-year plan that puts digitisation and innovation at the centre of a "process for the structural and radical transformation of the country". These initiatives, which require robust implementation over time as well as investments, may result in a progression of these Member States on the DESI in the coming years.

The Boston Consulting Group estimates the digital economy will reach $ 16 trillion by 2035. US dollars. A significant part of digitalization is in the sphere of consumption (services, e-commerce, offline shopping and online search) - 63 billion USD, in which the Internet of Things plays a huge role. The development of this segment cannot be considered outside the global trends of digital transformation. By 2025, the annual contribution of the Internet of Things to the global economy could be from 4 to 11 trillion. US dollars.

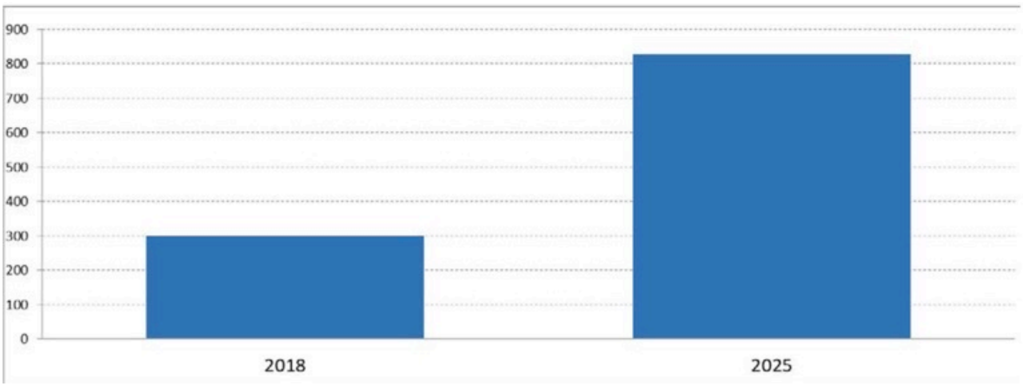


Figure 78. Size of data economy in EU27, 2018 vs. 2025, in € billion
Source: Digital Economy and Society Index (DESI) 2020

Data is an enabler of digital transformation and an accelerator of innovation for technologies such as the Internet of Things, artificial intelligence, cybersecurity or robotics. Large volumes of data are fuelling data-driven innovations. For example, they can help artificial intelligence to make breakthroughs in machine learning, as massive amounts of data are needed to train neural networks. Likewise, using HPC and cloud computing together can make it possible to access and develop advanced analyses of large amounts of data in a very short time.

The volume of data produced in the world is growing rapidly, from 33 zettabytes in 2018 to an expected 175 zettabytes in 2025. It is estimated that the EU27's data economy (the overall impacts of the data market on the economy as a whole) exceeded the threshold of €300 billion in 2018, up nearly 12% over the previous year. In addition, it is expected to reach €829 billion by 2025, accounting for 5.8% of EU GDP(52). There were 5.7 million data professionals in the EU27 in 2018, and this figure is soon expected to double, reaching 10.9 million people by 2025.

The IMD World Digital Competitiveness Ranking presents the 2020 overall rankings for the 63 economies covered by the WCY. The rankings are calculated on the basis of the 52 ranked criteria: 32 Hard and 20 Surveydata. The countries are ranked from the most to the least digital competitive and the results from the previous year's scoreboard (2019) are shown in brackets. The index value or "score" is also indicated for each country.

Among the studied countries, the USA consistently takes 1st place, Germany is in 18th place. Ukraine improved its performance by 2 positions and in 2020 took 48th place. Georgia is not yet included in this rating, which indicates the need to improve and improve the direction of digitalization.

Figure. 79. Digital competitiveness ranking 2018
Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2020.

Figure. 80. Digital competitiveness ranking 2019
Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2020.

In 2020, USA held the top position for the third consecutive year. Singapore held the 2nd spot, while Denmark overtook Sweden to claim 3rd place. Hong Kong climbed three ranks to 5th, and Switzerland dropped one place to claim the 6th spot. 2020 has been a challenging year for the world. Every aspect of our lives has been affected by COVID-19 and technology has been incorporated to address the pandemic in different dimensions from communication to monitoring, assessing and, hopefully in the non-distant future, finding a cure for the virus.

For most countries the responses of our survey were acquired during the first wave of COVID-19. To be clear, the questions we ask do not refer specifically to issues related to the pandemic. Still, if technology is the most important tool in our battle against the pandemic, some of the trends we identify have an added significance. For 2020, economies that top our ranking focus on building their talent pool and thus strengthen the knowledge infrastructure necessary to develop and employ digital technology with Singapore, Switzerland, and the Netherlands holding the top three positions respectively.

In addition, most leading economies in our ranking provide an effective regulatory framework that enables the development and introduction of technologies. Singapore, Norway, UAE and Denmark capture the top four places in this sub-factor.

Figure. 81. Digital competitiveness ranking 2019
Source: 5. Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2020.

Finally, top performers in digital competitiveness also combine individual adaptability with business agility in their economies. The Republic of Korea, Denmark and the USA excel in the dimension of individual adaptive attitudes while Taiwan-China, the USA, the Republic of Korea and China capture the four highest places in the area of business agility.

Digitalization of tourism can be divided into external and internal. In the first case, we are talking about the systematic transfer of communications with the client into a digital environment. Typically, this is the travel agent's website, which can also host a special chatbot for communicating with the tourist. The fact is that today people want to quickly and easily get the information they need, no one wants to waste extra time that can be shortened. One of these frills is going to a travel agency. Therefore, of course, when choosing to go to an agency or open the Internet, an ordinary tourist will choose the latter.

But the site functions in the same way as the agency. There, the user will not be left alone with questions either: an employee immediately connects to a chat or a chat bot. The main thing that the client pays for in such a situation is efficiency and efficiency in communication. Therefore, the site should be as clear and simple as possible, and navigation on it should be convenient. All updates on the site must be made in a timely manner, communication with the client is configured and debugged for a quick response and answers to all questions.

Accordingly, the number of independent tourists is also growing. Services for the search and sale of tickets and hotels note the interest of tourists in independent travel instead of ready-made package tours. At the same time, the growth of the flow itself is estimated differently by different resources - from 15 to 70%. Thus, according to the airline ticket search engine Aviasales, on average, the number of online bookings increased by 70% over the year, with about 60% of sales accounted for by domestic flights.

Travel agencies rarely use this resource, so it can be assumed that the main growth is accounted for by independent travelers. Tourists use online travel planning services, the share of bookings for which is only growing (not considering the period of the pandemic).

Online sales continued to grow before stagnation in the industry, and there are two directions for them. First, people buy tickets and hotels separately, making up their own trip. Secondly, travel agencies are also going online, promoting their own bundled tours. In addition to booking and organizing communication with tourists, digital technologies make it possible to engage in post-support, that is, accompanying and receiving feedback. The customer's journey is tracked at all stages, including the assessment on the service for different positions.

Internal digitalization is aimed at the development of CRM systems, automatic tools for setting tasks and planning. This is becoming an important factor in increasing the competitiveness of firms. Automation of such processes frees up time for other work, for example, studying new technologies or mastering other related areas for application in the work of the agency. The latter is now becoming especially relevant, since only those organizations that expand the boundaries of sources of income will reach a new level and survive the crisis of the system.

The trend of abandoning the classic sales scheme is gaining momentum. Travelers buy flights en masse using the SkyScanner service, and hotels book on Booking.com.

There are other applications for obtaining the necessary travel documents: for example, the Tripinsurance service allows you to issue a policy within a few minutes. The matter is not limited to the issuance of a document: within the framework of insurance, you can get a round-the-clock emergency consultation from a suitable doctor. Communication with customers in Tripinsurance is also in Ukraine. Support specialists use all major instant messengers.

Transfer companies are also developing online, for example the transfer company GetTransfer.com, which offers services in all popular tourist cities. Recently, the GetTransfer.com service has started operating in Africa.

Translators and sightseeing services go to applications. Services with audio guides (IZI.travel), various online formats of exhibitions and entertainment, virtual tours and even live broadcasts are popular.

A Booking.com study found that a third of the world's traveler audience is interested in AI-assisted travel planning. People enter all the necessary information about themselves into the system. 50% of respondents did not care who helps in planning a trip - a live operator or a chatbot. If the service of choosing a tour or booking a hotel offers a suitable option, then the likelihood of its purchase increases significantly. Large online services will continue to develop their own artificial intelligence, and their experience is gradually being taken up by smaller players.

Artificial Intelligence is a huge opportunity and a versatile platform that helps provide a personalized service to each tourist. And this is what the entire service sector strives for. Taking into account the individual desires of the client is what agencies are striving for today.

Modern AI systems eliminate the need to be constantly ready to respond to a customer's request: they allow you to act predictively, relying on predictive tools, that is, they are systems that can suggest the best time to buy plane tickets and book hotel rooms or the best time of the year to travel. to the selected country.

If you constantly supply the AI system in the travel industry with new information, train it, give it access to up-to-date databases, the possibilities for personalizing the service will become almost limitless.

Individual networks are introducing their own products as part of digitalization. For example, by 2020 it will become clear how effective the tested HiltonHonors technology is: this is an application in which the guest selects a room, pays for it, and fully adapts the accommodation to their own needs.

Blockchain is another popular technology that does not depend on market volatility. It contains innovations that are useful for the tourism industry, which have already been noticed. Blockchain is, first of all, the security of making transparent transactions without the participation of banking structures of different countries, the chance of a sudden blocking of the card, while there is the possibility of protecting your cryptocurrency wallet with at least two-factor authorization.

For a tourist, there is the prospect of long trips without the need to carry documents and a wallet with them.

Blockchain transactions will not solve the security issue once and for all - but at least offer a convenient alternative.

The other side of using the blockchain is the collection and storage in a single space of data on purchased tickets, booked rooms, used loyalty programs, routes and more. Such information is needed by all representatives of the industry, because knowledge about the actual preferences of tourists gives the ability to predict their desires, and therefore, to raise their own conversion.

Internet of Things (IoT)

The Internet of Things refers to the interaction of electronic devices capable of sending and receiving data over the Internet. Basically, it is a network of networks in which people can communicate with devices, and devices can communicate with each other, react to changes in the environment and make decisions without human intervention. IoT devices function on their own, although people can configure them or provide access to data. IoT systems operate in real time and usually consist of a network of smart devices and a cloud platform to which they are connected via Wi-Fi, Bluetooth, or other forms of communication. The devices first collect data - for example, about the temperature in an apartment or the user's heart rate - and then this data is sent to the cloud. There the software processes them. What happens when the temperature gets too high or there is a burglar in the house? The system notifies the user about this or itself performs further actions - for example, calls the police.

Many people associate the Internet of Things with a "smart" home. Thanks to technologies and devices developed by Google, Yandex, Amazon, Apple and others, users can make online purchases, adjust the temperature in the room, turn on the lights and music, and give voice commands to virtual assistants. You no longer need to worry that you forgot to turn off the iron or tap - just press a button on your smartphone, and the smart home will fix everything. The computer vision surveillance system will recognize everyone who passes by your apartment and compare the images with the police base. Today, a "smart" home in Ukraine is basically Yandex's intellectual assistant "Alice", which turns on music, searches for information on the Internet, advises films, adjusts the lighting and temperature in the house, and turns on the kettle.

IoT enables companies to automate processes and reduce labor costs. This reduces the volume of waste, improves the quality of services provided, and makes the production process and logistics cheaper. IoT affects all industries. The introduction of the Internet of Things in the electric power industry improves the controllability of substations and power lines due to remote monitoring, and in healthcare it allows to move to a new level of diagnostics of diseases - “smart” devices monitor the patient's health indicators. In agriculture, smart farms and greenhouses meter fertilizer and water on their own. The introduction of IoT in logistics reduces the cost of transportation and minimizes the impact of the human factor. IoT is actively implemented in the oil and gas and mining industries. For example, the use of in-depth analytics on boreholes is helping the oil and gas industry to increase production from already depleted fields. And the Internet of Things in transport is the transport itself, electronic displays, navigators, security systems, surveillance cameras that interact with each other.

However, humans cannot directly interact with the Internet of Things. We don't have processors like a computer. But we have mobile devices through which we can exchange digital information.

It is through this communication channel that tourists can adapt different aspects of their journey for themselves. These can be some simple actions: set the temperature in the room, order room service in advance, even before arrival, turn on or off the light, receive notifications about the status of the flight in real time.

Mobile technology

According to the GSMA, more than two-thirds of the world's population, that is, 5 billion people, use the services of mobile operators.

RBC's research, which was attended by 11 thousand respondents from 19 countries, showed how important mobile technologies are for the modern tourist. 33% of travelers book tours, hotels and tickets through mobile devices, 62% admit that e-tickets and boarding passes make travel much easier, 46% say that the availability of e-services influences the choice of an airline.

The mobile device becomes a personal travel assistant. From the moment you start searching for services until the moment you return, it determines how pleasant the experience will be for individual services or the trip as a whole.

Mobile devices are the means of continuous personal interaction. They allow offering tourists different service options depending on the personal preference or location of the client. But for a mobile device to understand the needs of the owner, it - the device - needs a mind.

BigData

⇒ According to IBM research, 90% of all information was created in the past two years. Methods of transferring, analyzing, using information have evolved to such extent that working with BigData technology has become a common practice.

⇒ Access to data is not only beneficial for our customers - travel companies can use data to better understand which approaches work and which don't. Data is the fuel for marketing in the twenty-first century. So, in the tourism industry, we can anticipate the next actions of our clients even before they decide what they will do. This is achieved through predictive analytics and analysis of complex data sets, such as travel history or demographic characteristics.

⇒ To use all this data, we need access to a lot of computing power. Some of them can be provided to us by the cloud infrastructure.

⇒ Cloud computing

⇒ Cloud computing gives us the infrastructure to process large amounts of data quickly, cost-effectively and on time.

⇒ It is the glue that connects all participants in the travel industry, making it relatively easy to move data and content, as well as process information and deliver it as close to the consumer as possible from a geographic point of view.

⇒ After all, cloud computing has enough bandwidth to enable us to operate efficiently even during periods of very high traffic, while providing additional value to our tourists.

⇒ The increase in consumers of services today is through communication through the Internet and social networks.

⇒ According to statistics, the three most preferred (and effective) marketing channels in the travel industry are e-mail, SMS marketing and phone calls, with e-mail being roughly twice as fast as its pursuers.

⇒ Therefore, travel agencies use:

⇒ the method of "reaching out" to as many tourists as possible, and not with random, but with interesting offers;

⇒ convert tourists who made one purchase into loyal customers;

⇒ work with an e-mail channel: create a content plan, increase the subscriber base, segment and control it.

This is achieved using:

Position diagnostics

To understand what prevents an organization from collecting all existing and potential customers in its e-mail list and using email as an effective sales channel, you need to ask yourself the following questions:

⇒ Does your site have a subscription form for your company's newsletter?

⇒ Is there an explanation of how often the client will receive letters from you and what will be in them?

⇒ How quickly and conveniently can a client fill out the subscription form for your newsletter?

⇒ Do you talk about your newsletter and its content on the site, in personal communication with the client / in correspondence with him?

⇒ Do you offer the client to subscribe to your newsletter at the first order?

⇒ Do you take email addresses of tourists when you work with them? Are you “friends” in social networks? Skype, Viber?

⇒ Do you have social media buttons, current quotes, website updates?

Ideally, you should give at least 4-5 positive answers.

Motivation for action

If finding new subscribers is a priority for your company, start by looking for points of contact between your company and your customers. See which pages on your site are attracting the most traffic. Perhaps it will be offers for family vacations, extreme tours, sightseeing tours? .. Make sure that these pages contain a convenient form for subscribing to an e-mail newsletter. You can add an alert that subscribers will receive exactly the offers for family vacations.

Tell us why they need it. Make sure that customers clearly understand why they should provide you with their email address and other information. Will you send them tips on how to plan a budget trip? A weekly email with a selection of photos of various travel destinations? Hot deals? Tell them, and then follow through on the promise.

Offer to subscribe to the newsletter not only on the website, but also on social networks and in person.

To receive a client's e-mail, transfer to the online part of the "paper" work (receipts, contract, necessary documents).

Segmentation and updating of the customer base

If you are already promising something specific to your subscribers, try to stick to the initial agreements so that customers do not feel cheated.

For this:

⇒ carefully maintain the customer base, record the history of customers' travels, their preferences - based on personal communication;

⇒ if possible - research his interests (social networks, account in TripAdvisor ...);

⇒ consider what type of mailing list the client subscribed to if you make such a division.

Constantly - weekly, monthly - analyze statistics. Key indicators are the percentage of mailing openings and the percentage of clicks on the link. The average rate of openings for the tourism and travel industry is about 17%, clicks - about 9.5%. This is individual, but consider this a waterline to stick to.

And further. Customers are chilling about your newsletter. They leave for another travel company. Change the email box. Change jobs (which is important if you only have a working client e-mail). In short, customers are lost, and so that the statistics you collect are not useless, update the data regularly.

Content plan and sales

Let's move on to the most interesting: active work with the database and sales through the e-mail channel. You can successfully sell destinations, tours and even simple ideas through e-mails if you have a competent content plan. So remember, planning is our everything.

Consider a content plan

Deciding at the last minute “what to put on your mailing list” is difficult and ineffective. This way you can send the client a good offer too early or, conversely, too late. Or even send content that is completely uninteresting to the tourist.

The main advantage of planning is the ability to divide the tourism product into segments: to whom and what is interested, at what time is the best time to send, say, excursion tours in Scandinavia, and at what time - a resort vacation in Spain.

Additionally, prepare interesting accompanying content related to the direction you want to sell.

It should include:

⇒ key attractions and entertainment;

⇒ information about cities / regions / routes;

⇒ information about events - festivals, national holidays, seasonal events.

You can use news from your partners that are interesting for tourists - news and offers from suppliers, hotels, restaurants, airlines.

It is very important to find a balance between advertising and informational content. If you collect materials of various types in an e-mail newsletter, you can test which one is the most effective and interesting to your customers.

Leverage customer locations

Do you know where your tourists live and what they see every day on the way to work, home? Use this and hit your target with promotional emails. For example, an offer to go to a sunny and warm resort for a week can be very effective when it is cold and cloudy outside.

Choose “speaking” illustrations

High-quality images are a great way to promote your product (your cap), and not just because “picture” replaces a thousand words. High-quality visual content evokes emotions and helps the client to immerse themselves in the material. Use images that help tourists better imagine the experience they will get on the trip - it can be photos of landscapes, cities, entertainment.

Decide on timing

Set the optimal time to prepare and send your e-mail offers. If you send an offer too early or, conversely, too late, you should not count on phenomenal success.

If you want tourists to visit the advertised destination in July, "prepare the ground", you need to send out the relevant information content and offers at least from April, at least a couple of months before the trip. Then there will be time for making a decision, planning, and, if necessary, applying for a visa.

If the base is segmented and all the interests of tourists are taken into account, offers "at the last minute", 2-3 weeks in advance, can be effective.

Thus, in order to achieve an increase in the subscriber base and turn e-mail newsletters into a channel for promoting your travel product:

⇒ check whether it is easy to find the subscription form on your site and whether the client understands why he needs it;

⇒ find points of contact with the client - website pages, social media pages, personal communication - and use them to collect a database;

⇒ study the interests of your tourists, segment, update the subscriber base;

⇒ create both advertising and informational content, experiment with it, plan a good time to send.

Let's go through the technologies that are created by countries that receive tourists.

The first digital services for tourists appeared in the early 2000s, at the dawn of the dot-com era - they were online booking and ticketing systems such as Booking, Airbnb or Aviasales. It is difficult to imagine modern travel without the use of such platforms.

According to Google statistics, during the travel planning period, users make about 400 searches. This huge reservoir of data is actively used by travel companies in order to influence our decision and persuade in favor of a particular route, company and hotel.

74% of the world's travelers plan their trip online. Turkey, for example, has announced a course for the development of "tourism 4.0" - the country intends to invest heavily in digital marketing for its tourism industry.

Asian countries, where tourism makes a significant contribution to their economies, have embarked on a digital transformation at the government level. In June, Sri Lanka announced the launch of a large-scale digital promo of the country as an attractive tourist destination, thanks to which the authorities plan to attract 2.5 million tourists this year. In Indonesia, in response to international expansion, Airbnb, with government support, launched its own guesthouse and villa booking network, Indonesia Travel Exchange (ITX), which already has 2,000 different rental properties.

There are dozens of technology start-ups in the tourism industry around the world that are striving to bring their original ideas to the industry. For example, the Cambodian platform CamboTicket, recently awarded another grant, makes it possible by email to reserve a seat on buses, ferries and private taxi services in Cambodia, Laos, Vietnam and Thailand at the same time. Thai startup LocalAlike is promoting a new concept of local tourism: through an online platform, the company hopes to bring together and advise locals around the world who have a lot to offer tourists. LocalAlike recently received a cash prize from Booking.com to develop its concept.

Many travel startups are trying to find their niche by focusing on a particular type of tourism, such as food or medical tourism. For example, the French platform Tripnparty allows travelers to find authentic bars and pubs in any country that only locals are usually well aware of, data are presented for many European cities.

In mid-June, a startup contest StartupWeekendBali was held in Bali, during which the best ideas in the field of tourism were selected. If you look at the list of winners, it becomes clear that the trend towards satisfying niche demands is very strong right now. So, the jury awarded startups BotolWisata (a database of Indonesian hotels that provide guests with clean water in renewable containers), FingerFarm (an application for tourists to buy products from local farmers), Travelis (an application for communicating with local drivers and guides in Bali), and so on. Further.

Well, the most ambitious startup in our selection was invented in Finland. The SpaceNation service has set itself the goal of neither more nor less - the popularization of space tourism, primarily on the ISS. By the way, one of the project's marketers is the brilliant Peter Westerbek, who helped Rovio make the AngryBirds game what it is now. "How can you restrict access to the ISS only to a certain circle of people?" - asks Westerbek. What SpaceNation offers is a virtual reality game.

The face of Amadeus is also changing. For a long time, this company was known in the market primarily as the Global Airline Ticket Distribution System (GDS). Today Amadeus operates in 190 countries around the world. The staff is 19 thousand employees.

Last year we announced a new development strategy - AmadeusLiveTravelSpace. Its core will be AmadeusTravelPlatform, which we are developing now. It combines almost all the content that is in demand in the travel industry: air and railway tickets, hotels, transfers, offers from cruise companies, insurance services, car rental, various services at resorts. Thus, we provide the widest possible choice for our clients - travel companies. So that they can book online any necessary service or their combination at one site. Both suppliers and agencies can connect to the system via standard interfaces.

“Such a multi-platform is exactly what is now in demand on the market. By implementing this concept, we are following the trend set by the world's top four technology industry leaders - Google, Apple, Facebook and Amazon. Only we do it in a narrower segment - tourism, and in the B2B format, ”says Leonid Marmer, General Director of Amadeus Information Technologies LLC, which represents in Ukraine the international company Amadeus, a leading provider of IT solutions for the tourism and passenger transportation industry.

He also highlights the following trends in the sphere, some of which we have already written about above.

Today in the world more than 60% of search queries are performed from mobile devices - smartphones and tablets. 52% of travel bookings are made online. The share of such requests and transactions will only grow, because the main consumers, including in tourism, are the generation of millennials who can no longer imagine their life without Internet technologies. And people of an even younger age, who will soon also start earning money and be able to afford travel, may even switch to ordering services exclusively online.

Personalization of offers. In the modern world, streams of information fall on people every day. Service providers - airlines, hotels, etc. - have to seriously think about how to make their offers targeted, otherwise they cease to be perceived by customers. To do this, you need to find out the preferences of the audience. For example, what is the point of announcing business class flights to someone who flies only in economy? It is easiest to collect information about preferences from the end consumers themselves, so suppliers will increasingly tend to go to them directly, bypassing intermediaries.

Development of online payments. Tourists are less likely to visit not only travel agencies, but also banks. Services booked from a mobile device, and it is convenient to pay from it. We expect rapid development of instant payment platforms. Amadeus, by the way, also has developments in this direction - both for smartphones and for other devices: watches, bracelets, key fobs.

Integration of the most diverse travel content on common platforms. The world is moving towards universality. Gone are the days when tour operators had reason to be proud of the fact that they work with a dozen or more online providers. Today this means insufficient manufacturability and irrational use of labor resources. And consumers, for their part, want to be able to book any travel service or a combination of them on one site.

Innovation in customer communication. Call centers, which often employ many employees, are being replaced by artificial intelligence. Air carriers, cruise companies, and other travel service providers are actively introducing chatbots. To clarify the flight schedule, the conditions for booking a hotel, to get advice, the tourist communicates not with a living person, but with a car that will competently answer all questions. Personal voice assistants are already being developed, including those with the owner's speech recognition function.

The arrival of the "Internet of Things" in the travel industry. And it's time to talk not so much about InternetofThings as about InternetofEveryThing. There are a lot of examples of possible use. Here's just one: the baggage is supplied with special sensors, and in the event of its loss, the tourist will receive a corresponding message.

Restructuring business processes, and above all their own consciousness and thinking - this is what companies should strive for, which want to stay on the tourism market. Otherwise, the next generation of tourists will not come to them, because they will not be of interest to them.

Technology will only continue to evolve; those who are not in trend will leave the market altogether, especially after the crisis. In today's emerging conditions, all companies are forced to survive and come up with various ways of restructuring their business, this is helped by the development of IT, which involves earning money even on difficult days through the correct investment of their own funds and efforts.

But, on the other hand, you don't need to get too carried away with the development of your own technologies. It is long, expensive, and most importantly, hardly advisable. Because it is almost impossible to create a product better or at least at the level of the world leaders in the IT industry. It is more correct to adapt the solutions they offer to your needs. After all, connecting to modern and technological online platforms is not so expensive, even not the largest travel company can afford it.

Versatility is a must now. The travel agent must be able to offer the client an online booking not only of a standard tour package from a tour operator, but also of any individual service or a set of them, adjusting to the wishes of the tourist.

The tourism business is optimistic about the development of technology and involves all the new options that now seem to be fantastic.

A serious problem of tourist business all over the world is how to resolve situations called disruption. Perhaps the most accurate translation of this term is "something went wrong". For example, a tourist has a delayed or canceled flight. Or the transfer was disrupted. Or, for one reason or another, he was not checked into a hotel at one of the points of a difficult route. All further travel logistics are disrupted. Now, in order to find a way out for such problems, it often takes titanic efforts of managers and leaders of travel companies. But already on the way are IT systems with artificial intelligence, which will promptly provide an optimal solution.

Airport fingerprint check-in will soon become a reality. Technologies based on face recognition are actively developing: at Amadeus, a similar solution, which allows boarding an aircraft, is already operating in one of the air hubs. Payment solutions are also being tested - for example, SmileandPay kiosks from one of the American companies: to deposit money for a service, all you have to do is smile at the camera.

And Uber has developed a prototype selfdriving drone. This is an unmanned flying taxi that will pick up travelers from the airport and take them to the resort.

But what exists today, even 10 years ago, seemed impossible. Therefore, one has only to observe the development of digital and IT technologies, getting ready to apply them in their activities.

REFERENCES

1. Seligman, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, 11(2), 37-48. **DOI: 10.14254/2071-8330.2018/11-2/3**
2. Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2020.
3. The IMD World Digital Competitiveness Ranking 2020 results https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2020/
4. Yuriy Kyrylov, Viktoriia Hranovska, Hanna Zhosan, Inna Dotsenko, (2020) Innovative Development of Agrarian Enterprises of Ukraine in the Context of the Fourth Industrial Revolution. *Solid State Technology.* Volume: 63 Issue: 6.

Publication Year: pp. 1430-1448. http://solidstatetechnology.us/index.php/JSST/article/view/2218

5. Жосан Г.В. (2020) Стан розвитку діджиталізації в Україні. *Економічний аналіз.* Том 30. № 1. Частина 2. С. 44-52. https://www.econa.org.ua/index.php/ econa/article/view/1792/6565656864
6. Кирилов Ю.Є., Грановська В.Г., Крикунова В.М., Жосан Г.В., Бойко В.О. (2020) Цифрова економіка. Криптовалюти: навчальний посібник. Херсон: ОЛДІ-ПЛЮС, 228 с.
7. Digital Economy and Society Index (DESI) 2020. Thematic chapters
8. Chen, Y. and Liu, L. (2017). Interaction and Integration of Cultural Inheritance, Ecotourism, and Industrial Development. Strategies, Mechanisms and Spatial Practice of The Amis Dietary Culture Transformed into Creativity Living Industry, *International Review for Spatial Planning and Sustainable Development*,5(3), pp. 66–78.
9. Mondino, E. and Beery, T. (2018). Ecotourism as a learning tool for sustainable development. The case of Monviso Transboundary Biosphere Reserve, Italy, *Journal of Ecotourism*, 18(2), 107-121.
10. Morgera, E., Razzaque, J. and Peralta, N. (2017). Ecotourism, Biodiversity and Nature Protection Law, available at:https://doi.org/10.4337/9781783474257.iii.27.
11. Natalia, P., Yosef, M. and Halog, A. (2019). Identification, Characterization and Stakeholder Analysis of Eco-tourism Destinations in Lake Toba Area, *International Journal of Tourism & Hospitality in Asia Pacific*, 2(81), pp. 1–10.
12. Nigar, N. (2017), Ecotourism for Sustainable Development in Gilgit-BaltistanProspects under CPEC.
13. Pan, S., Gao, M., Kim, H., Shah, K.J., Pei, S. and Chiang, P. (2018). Science of the Total Environment Advances and challenges in sustainabletourism toward a green economy, *Science of the Total Environment*, 635, pp. 452–469.
14. Qiu, H., Fan, D.X.F., Lyu, J., Lin, P.M.C. and Jenkins, C.L. (2018). Analyzing the Economic Sustainability of Tourism Development: Evidence from Hong Kong, *Journal of Hospitality and Tourism Research*, 43(2):226-248.
15. e-Review of Tourism Research (eRTR), Vol. 18, No. 2, 2020http://ertr.tamu.edu233
16. Грановська В.Г., Алєщенко Л.О. (2019) Агротуризм як інструмент диверсифікації діяльності агроформувань. Економіка АПК. № 12. С. 28
17. Кирилов Ю.Є., Грановська В.Г., Алєщенко Л.О. (2020) Економічний механізм формування конкурентних переваг суб'єктів туристичної галузі. *Економіка АПК.* № 5. С. 45-55. DOI: https://doi.org/10.32317/2221-1055.202005045.

VIII. PROSPECTS FOR THE DEVELOPMENT OF «GREEN» AND «BLUE» BUSINESS

8.1 Digital Technologies Take Effect on «Green Business» Progress

Halyna Synytsyna,
Ph.D. in Economics,
Head of the department of Entrepreneurship and Exchange Activities
State Biotechnological University
E-mail: sinicina_galina@ukr.net
ORCIDID0000-0002-7898-3823

Olena Fylypenko,
Ph.D. in Economics,
Professor of department of Economics and Business,
State Biotechnological University
E-mail:emfil@ukr.net
ORCID ID0000-0002-0647-881X

In view of the ever-growing environmental issues and rapid digitalization of business, industrial ventures face an important mission of finding some balance between an advancement of existing business patterns based on digital technologies and a minimization of negative environmental consequences during their economic activity. Requirements of stakeholders for a high-quality transformation approach and introduction of information and communication technologies (ICT) for industrial ventures as well as the environmental friendliness approach used in their activities actualize the process of environmental friendliness mechanism based on the «green business» concept and a need to expand ICT in communication business management.

Works of G. Daley, O. Amosha, O. Baluyeva, M. Moiseyeva, M. Pashkevych, and O. Sadchenko are devoted to studies of economic and ecological systems of both a national and regional scope.The issues of enterprise management based on the ecological approach were developed in the scientific works of N. Andreeva, A. Bardas, O. Veklych, O. Popova, A. Sadekov, D. Smolennikov, S. Kharichkov, E. Khlobystov.

At the same time the issues of determining a degree of environmental friendliness of industrial enterprises and establishing the grain of their impact on an external environment as well as the outcomes of economic activity of the entities still remain insufficiently developed in scientific literature.

Theoretical and methodological aspects of business process digitalization were enlightened in the works of such foreign scientists as: M. Blix, Ch.Gupta, H. Kroll, L. Hounshell, D. Horvat, A. Jäger, F. Bergeron, L. Raymond, A. Croteau, M. Brettel, N.

Friederichsen, M. Keller, M. Rosenberg, K. Schwab,etc.The works of domestic scientists, in particular, V. Bozhkova, O. Volot, V. Kasyanenko, O. Kireva, K. Kovtunenko, O. Kopiyka, L. Melnyk, A. Orekhova, G. Pocheptsova, I. Sotnyk, K Tanashchuk, L. Taranyuk, etc. are preoccupied with the researched domain.

At the same time the problems of ICT implementation in industrial enterprise management, development of approaches to substantiation and optimization of decision-making on digitalization of communication business processes, enhancement of organizational and economic principles of communication business management still remain unsolved. Modern industrial production is one of significant sources of the anthropogenic impact on an environment. The influence of industrial factors has a decisive effect on transformation of the biosphere due to the presence of complex and diverse links between a human habitat and its productive activity.

Firstly, a natural environment is a global spatial basis, in limits and according to the terms of which any human activity takes place, including industry. Secondly, the properties of the natural environment in a considerable degree affect forming of a complex system of unreasonable requirements and requests of humanity to ensure safety, quality, durability, comfort of human existence, and thus, define the hierarchy of real emerging human needs (objective and subjective, social and individual) which require the satisfaction. Thirdly, the natural environment is the main source of resource support for human life, that is, a great storage of natural resources, the use of which is highly necessary for the society for satisfaction of continuously growing needs of its members. However, the global (in relation to the existing limits of the human habitat) character of existence of natural environment until about a middle of the past century determined the nature of the attitude of people to the state of the biosphere based on the human needs. Under such conditions, the interests of society in the relations with the natural environment were usually limited to a strictly «consumer» orientation.

Until recently environmental management has been considered to be the process of natural resource exploitation for a merely pragmatic purpose of meeting material and cultural needs of a society. The rational use of natural resources presupposed reliance on reason and knowledge as the use of nature has been always considered as a separate science which studies general principles of any human activity related to the use of natural resources or transformation of their state [1; 2].

Interaction and structural binding of a society, industrial relations and the environment under the technogenic system «production – consumption» [3, p. 66] which operation is based on amere exploitation of natural factors (artificial disruption of a natural environment) are due to the complexity and diversity of the process of natural factor use in the process of productive human activity.

It is noted in scientific works [4-8] that the paradigm of social and economic development based on technocratic-consumer attitude to nature is the main reason for imminent destruction of the biosphere, ozone depletion, climate instability increase, flora and fauna impoverishment. According to Z. Gerasimchuk [9, p. 62] it is the growth of anthropogenic pressure on the biosphere in the process of social development that causes a sharp aggravation of the environmental situation on a global scale which brings humanity closer to a critical limit in interaction with nature.

Yu. Stadnytsky [10, p. 75] also believes that anthropogenic pollution is currently one of the main global pressing problems of human development around the world in general and Ukraine in particular. The negative effects of anthropogenic pollution which until the middle of the last century were often considered insignificant «external effects» and could be neglected while choosing the optimal technologies or trying to justify the economic development increase one of the greatest threats to human welfare and security. The author also insists that a reduction of anthropogenic pollution by a society is of almost no technological or technical difficulties. In his opinion the answer to this problem is a merely economic task the complexity of which is mainly due to the excessive cost of implementation measures to improve the environmental safety of production. Therefore, under current conditions the maximum attention should be paid to the optimal use of limited resources that can be used for environmental purposes.

V. Scherbak [11, p. 51] in its turn supposes that the technological progress of mankind still consists of a series of use-depletion cycles of resources each of which involves sequential passing of certain stages:

– developing (creation) and expansion of the previously unused («non-existing») natural resource base;

– exhausting of the used natural resource base and the result making worse in terms of existence of society in an environment, the search for reserves to renew or replace the resource base;

– replacement of the outdated resource and environmental base by new sources of natural resources (and also occurrence of new, generally, more acute and complex environmental and resource problems).

Today environmental activity intensification for the sake of social and economic development is of great importance not only at the macro level but also at regional and business levels. Thus, according to L. Maslovskaya [12, p. 64] with a general orientation of the state strategy of transition to the principles of sustainable development the territorial regulation of ecological management acquires a special relevance. Regions become a kind of economic, social and ecological core of geo-economic space as well as the sphere of mobilization of material, labor, financial and intellectual resources for this purpose [13-19]. It is at the regional level that it becomes quite expedient and possible to achieve the balance of structure and production scale with the structure and magnitude of the integrated natural resource potential as well as environmental priority establishment for its use.

Scientific approach analysis for economic and environmental study of activities and patterns of development as well as ecological and economic development of industrial enterprises [20-21] allow to identify such components (varieties) for their realization as social-psychological, organizational-structural, technical, technological, financial, commercial, communicative, informational, functional.

According to some authors industrial enterprise development on the basis of the concept of green business is its main environmental priority. At the turn of the new millennium there was a need for a new vision of a global environmental situation by the world community and an era of a «new responsibility» of all states for the earthly civilization safety. Former notions of «living for themselves», for the good of only their territories and peoples by limiting the interests of others have completely «played out».

Awareness of the environmental danger that threatens humanity has united the efforts of scientists, politicians and businessmen today to find a way out of this situation. Ecological balance preserving has become the main tendency in decision-making for the problems of environmental protection and business development. In 1987 the World Commission on Environment and Development established at the initiative of the UN General Assembly declared the problem of sustainable economic development and economic balance in their report «Our Common Future» as a general form of development and progress of the society. Meeting the needs of today's inhabitants of the Earth should not limit the ability of future generations for their existence. This means a transformation of human and financial resources as well as resources of animate and inanimate nature to meet reasonable needs of a man with a continuous improvement of his living conditions. Sustainable development requires new forms of financial cooperation and new ways of project financing. At the same time the «green industry» or «green sectors» of the economy are designed to materialize new sources of growth associated with an efficient use of natural resources and environmentally efficient technologies in ecological products and services and thus in added value and profits of companies engaged in these activities. Promoting their development and «greening» the traditional «brown» technologies and business models are central prerequisites of government strategies for the transition to a «greener» economy.

The global acceptance of technologies and methods that are less environmentally harmful has been recognized as vital for a further development of mankind and adoption and implementation of environmental standards, elimination of environmentally harmful subsidies for the resource use, energy and raw material price growth have stimulated a technological renewal aimed at its negative impact reduction which became known as «green business» and companies began to be called «green businesses» or «environmentally conscious businesses». At the same time these processes have led to a dynamic and rapid growth in a number of companies offering goods and services that increase resource efficiency, improve waste management and minimize environmental damage. These ventures appeared in all sectors of the economy and later became known as the «environmental goods and service sector» or «green» business (WB).

The ideology of «green» business fits well with a need to improve an environment at the same time ensuring economic development. «Green» or environmental business is a diversified area of business that can provide not only environmental but also significant economic effect on a national scale. Being an economic agent a source of employment and a key factor in economic and social well-being this sector cannot remain unchanged. In order to solve the problems of today and to ensure economic development while maintaining a high level of environmental quality we stake on greening the industry.

Today green business offers decisions for some of society's most pressing environmental problems:

– the design and construction of energy efficient buildings;

– the recycling and safe waste management;

– the development of renewable energy;

– and the wastewater treatment [22].

The Ukraine's economic system remains environmentally unfavorable. Ukraine ranks one of the first places in the world in terms of consumption of natural resources – energy, water, minerals – per unit of GDP. Ukraine's water resources consist of surface and groundwater. Surface fresh water bodies of Ukraine cover 24,1 thousand km^2, or 4,0 % of the total territory (603,7 thousand km^2) of the state. These include rivers, lakes, reservoirs, ponds, canals and more. There are 3,3 thousand rivers longer than 10 km; their total length is 94,4 thousand km. The average density of the river network is 0,34 km / km^2. Ukraine is one of the least water-supplied countries in Europe as the reserves of local resources of a river runoff per person are about 1,0 thousand m^3 per year.

According to the State Agency of Water Resources of Ukraine the supply of Poltava region with an average long-term river runoff (per 1 km^2) is 1788,2 thousand m^3 per year. Also, the discharge of return water into the surface water bodies of the region in 2017 amounted to 70 million m^3. Thus, the main factor of anthropogenic pressure on surface water resources is still significant volumes of water consumption for economic activities and discharges of polluted waters [23]. Taking into account such an environmental situation it is advisable to conduct a research on enterprises engaged in the production and installation of nature treatment facilities.

We made the research for the Production Cooperative «Environmental Enterprise» «Ecology» (Kovpaka Street, 21; Poltava, www.ecology.com.ua).

The environmental enterprise «Ecology» was established in 1990 to implement the latest domestic biotechnologies for domestic and industrial wastewater treatment. More than 400 facilities have been commissioned during the company's existence. The biological treatment technology developed by company's specialists was awarded with the State Prize of Ukraine in the field of science and technology. This patented technology formed the basis for creation of the «Dzherelo Wastewater Treatment Plant» that received a positive response from the Institute of Environmental Problems of the Ministry of Ecology and Natural Resources, the expert opinion from the State Labor Inspectorate and the hygienic opinion from the Ministry of Health of Ukraine.

The subject of activity of the PC EE «Ecology» is:

– the production of mobile block installations of biological water treatment of industrial and domestic sewage, their installation, adjustment, operation;

– the construction and installation works on maintenance and reconstruction of treatment facilities for biological treatment of domestic and industrial wastewater with the introduction of new biotechnologies;

– the engineering and technological development and implementation of new methods of biological treatment: industrial and domestic wastewater, reservoirs, rivers and bays; industrial gas emissions, soil and oil sludge and fuel oil pollution of equipment and communications with slag;

– the design works performance of biological treatment facilities;

– the realization of projects and blueprints on biological sewage treatment for enterprises, organizations and the population;

– the consultancy on biological wastewater treatment and design solutions;

– the educational and methodical training of specialists in biological wastewater treatment.

PC EE «Ecology» is an official representative of Ekofinn-Pol (Poland) and WavinLabko (Finland) in Ukraine.

One of priority problems of PC EE «Ecology» which answer requires a special attention of state environmental authorities, scientists and entrepreneurs is the adoption and implementation of water protection measures aimed at improving the ecological condition of rivers. The company occupies 25% of the domestic market of treatment facilities in terms of production. 39 % according to the results of our research is occupied by the Corporation «Energoresurs-Invest» (Lviv), 15 % – by LLC «Uniprof WW» (Lviv) (Fig. 82).

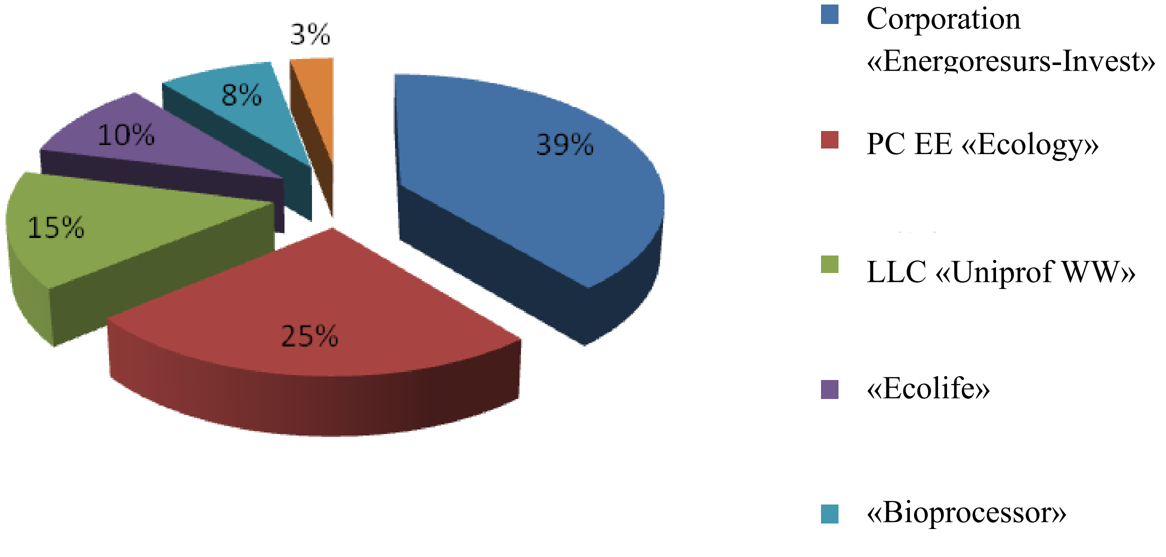


Figure 82. The structure of the water treatment facilities market in Ukraine
Source: Developed by the authors and based on the market research

It should be noted that water treatment and wastewater treatment technologies are the technologies of interest to scientific and business environment and the growth rate of both scientific publications and patent publications in many areas exceeds 400%and sometimes – 3000%. At the same time Ukrainian priorities lack advanced world tendencies: digitalization of management, control and provision of services in the field of water supply and sewerage; computerization of water supply and drainage, etc. Therefore, it is desirable to add these areas to the list of Ukrainian sectoral priorities especially regarding water supply and sewerage digitalization and water purification from organic pollutants [24].

Digital transformation is an introduction of modern technologies into business processes of a venture. This approach implies not only installation of modern equipment or software but also the fundamental changes in approaches to management, corporate culture, external communications. As a result, a productivity of each employee and a level of customer satisfaction increase and a company gains the reputation of a progressive and modern organization. The issue of digital transformation is quite difficult and wide by content, because the problems of technological development in one area motivate to the occurrence of problems in other areas. The first step to introduction and dissemination of digital technologies is needed realization of changes – of imperative caused of the imminent digital breakthrough, which allows the enterprise to improve its position in the market and significantly increase the value of innovative propositions [25].

Digitization of processes is relevant not only at the level of individual enterprises: entire industries choose their own path of development as the only way to meet rapidly changing conditions of the world. Due to this digital transformation of an industry is already changing the activities of every enterprise.

Customers are one of the main drivers of digitalization – many of them have already begun to transform their activities. By customer experience we mean not only interaction with foreign customers but also domestic customers. Digital transformation of processes optimizes the work of employees of a venture which increases the productivity of each individual team member. Digitization technologies allow you to organize personalized interaction in the most favorable way preferred by a customer. Digital communication channels, omnichannel, artificial intelligence, robotics provide more time to solve really important and complex tasks. Digitalization of business encourages innovative ways of a venture development, in particular:

1. Cloud technologies allow several teams to work on one project simultaneously and efficiently using the company's resources.

2. Using the Mobile First strategy companies receive and monetize mobile traffic which by its indicators has already caught up with the traffic of stationary devices.

Ready-made answers save time on tasks. Various programs, extensions and connectors optimize operation of a venture and require a minimal time for their implementation and adaptation.

In this regard the digitalization of water supply and sewerage namely the digitalization of installations and processes helps concerned companies to get the most of this process. Thus, Siemens has developed Digital Enterprise – a comprehensive portfolio of software and automated solutions. All available data processing within the framework of a complex data model allows to use all system optimum potential. Intellectual integration of data using a variety of sources such as sensors, water meters and meteorological data creates new opportunities for water use in industry. A prerequisite is end-to-end network organization of system engineering – from commissioning to operation, maintenance and optimization of a current process on the basis of a data platform – the integration of virtual and real worlds. An improved data quality and availability reduce project implementation time in the real world.

Thus, the requirements for domestic industrial ventures in the context of digitalization and globalization of world markets necessitate new effective decision-making for business digitalization (including «green business») to increase their competitiveness. It should be noted that possible social-economic and ecological-economic consequences of different priorities to production and consumption approaches of ecological products as well as a need for ecological regulation of production are illustrated by the matrix «benefits – losses» (Fig. 83).

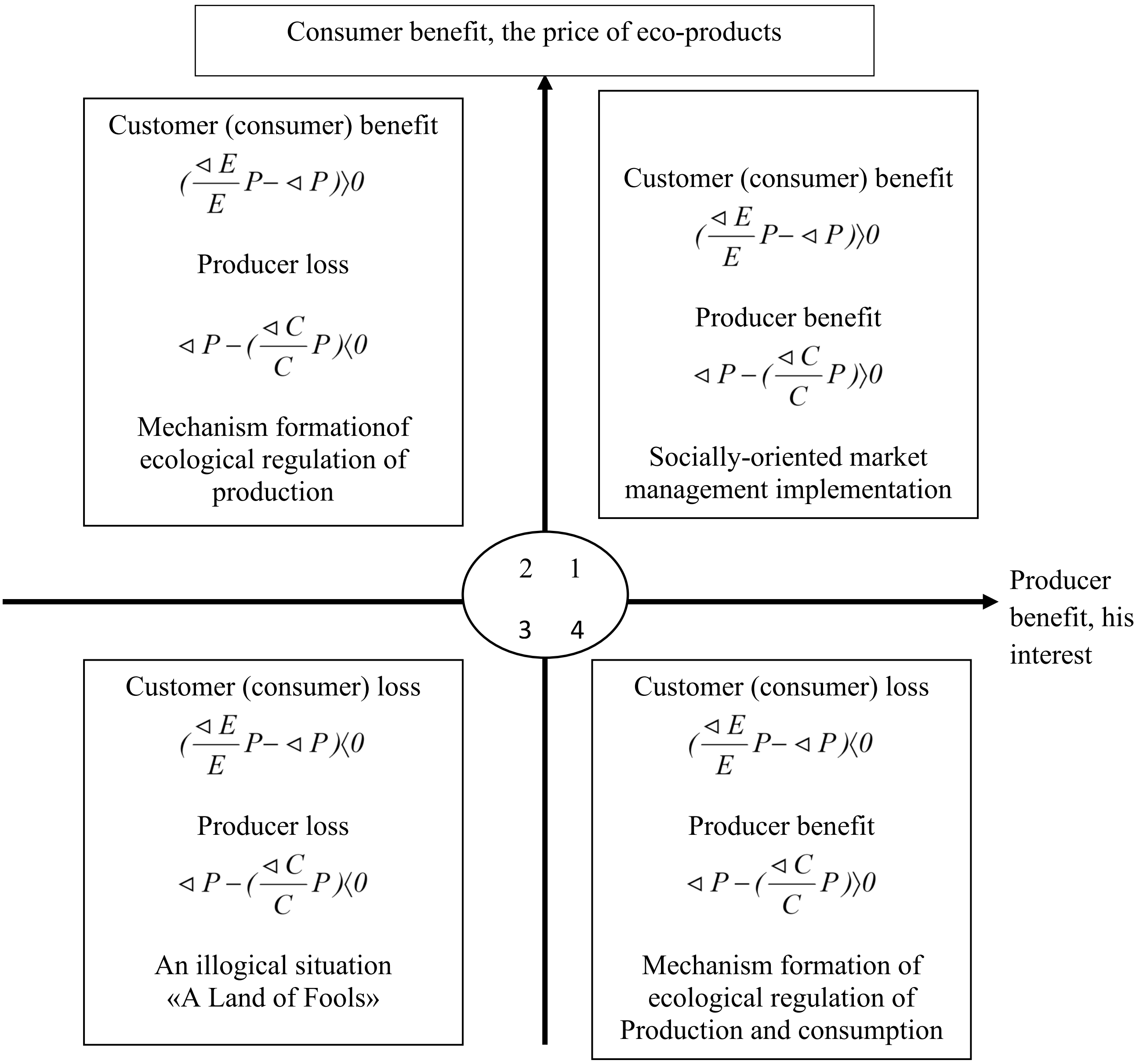


Figure 83. The matrix of ecological production «benefit-loss» of a producer and a client (consumer)

Source: Developed by the authors on the basis of the «buyer-seller» matrix by Igor Ansoff [26, p. 84].

If costs for environmental parameter up grading of a product quality increase in proportion to the level of environmental friendliness and, accordingly, the price increases the contradiction between the environmental and economic interests of a customer (consumer) and a manufacturer does not arise. In such a case a price does not encourage a manufacturer to improve quality. The demand for organic products is restrained.

In this case it is possible to set such a new price (P + ΔP) when a relative price increase is less than a relative increase in the level of environmental friendliness (quality) $(\frac{\lhd E}{E})$ and is above a relative increase in cost $(\frac{\lhd C}{C})$.

The given approach can be represented as follows:

$$\frac{\lhd R}{R} \geq \frac{\lhd E}{E} \rangle \frac{\lhd P}{P} \rangle \frac{\lhd C}{C}, \tag{1}$$

where R is reduction of external environmental costs of production and consumption;

$\frac{\lhd \ddot{I}}{\ddot{I}}$ – a relative reduction of external environmental costs.

The given ratio between quality (environmental friendliness) of production, its price and expenses is the best from the point of view of social and ecological interests of both a society as a whole.

The price in this case stimulates an increase of ecological quality of production and an increase in demand for it. In accordance with the growth of environmental friendliness of new products, external environmental costs (environmental and economic damage) are reduced both for an individual consumer and a society as a whole.

Let’s consider some conditions for economic and environmental interest coordination of a producer and a client (consumer). If a price for products of the high environmental quality for an individual consumer was specified in proportion to an increase in quality, i.e. if:

$$\frac{\lhd P}{P} = \frac{\lhd E}{E}, \text{ то } \lhd P_e = \frac{\lhd E}{E} \cdot P,$$

where ΔP_e is a price increase of an increase in ecological quality per value of ΔE.

If a price for these products would be specified in proportion to the cost, i.e. if:

$$\frac{\lhd P_c}{\lhd P} = \frac{\lhd C}{C}, \text{ то } \lhd P_c = \frac{\lhd C}{C} \cdot P,$$

where ΔP_c is a price increase of an increase in costs per value of ΔC.

The condition of interest coordination of an individual consumer and a producer looks like that:

$$\Delta P_e > \Delta P > \Delta P_c\,. \tag{2}$$

It is important to note that a manufacturer will benefit from:

$$\lhd P - \lhd P_c = \lhd P - \frac{\lhd C}{C} \cdot P, \tag{3}$$

and a consumer benefit will be as follows:

$$\lhd P_e - \lhd P = \frac{\lhd E}{E} \cdot P - \lhd P \cdot \tag{4}$$

The total benefit of both a producer and a client (consumer) is determined by value of:

$$\lhd P_e - \lhd P_c = \left(\frac{\lhd E}{E} - \frac{\lhd C}{C} \right) \cdot P \cdot \tag{5}$$

The amount of this total benefit can be divided into three parts: the benefit of an individual consumer, the benefit of a producer (a venture) and the benefit of a society (in particular, a state) as a whole.

Let us now consider in more detail a substantive basis of the quadrants of the matrix. Quadrant 1 «Customer (consumer) benefit, producer benefit» meets the principles of socially-oriented market economy and sustainable social-economic development and also reflects the system of long-term mutually beneficial relations «buyer – producer» as it is provided as a return on investment and satisfaction of social and ecological needs of a buyer within reasonable prices.

Quadrant 2 «Customer (buyer) benefit, producer loss» corresponds to the situation when external environmental costs of production, the lack of a positive effect assessment of production and consumption of organic products become the subject of environmental regulation of production from the standpoint of ecology friendliness stimulation of a single venture.

Quadrant 3 «Customer (consumer) loss, producer loss» corresponds to the situation which in the terminology of I. Ansoff is called «A Land of Fools» [26].

Quadrant 4 «Customer (consumer) loss, producer benefit» reflects the case when a producer receives some profit from sales but does not provide a consumer with a product which level of environmental quality would correspond to the price. This situation often occurs in industries with a low level of technological development.

However, such a situation may occur in the production of new goods in highly developed industries based on innovative technologies when interests of a buyer are not always taken into account.

Thus, the conceptual approach to ecological and economic development of an industrial enterprise taking into account the green business concept has been formulated on the basis of available theoretical support analysis. In accordance with the modern realities aimed at natural and economic resource use it has been determined that increasing the ecology friendly economic activity we ensure both effectiveness of environmental and economic activities of an enterprise and the program implementation of environmental and economic development of a region.

Digital transformation approach enables an accelerated adaptation of communication business processes of industrial enterprises to the challenges of an external environment making easier the work of a user, the quick response to customer (consumer) requests and an increase in productivity of all business processes of industrial enterprises.

REFERENCES

1. Halushkyna, T., Krutiakova, V. (1999). *Эkolohycheskaia polytyka y mekhanyzmы ee realyzatsyy na rehyonalnom urovne* [Environmental policy and mechanisms for its implementation at the regional level]. Odessa: Ynstytut problem rynka y эkonomyko-эkolohycheskykh yssledovanyi.
2. Karahodov, Y. (1998). *Эkonomycheskyi menedzhment pryrodopolzovanyia* [Economic management of nature management]. *Byznes-Ynform*, 19, 3-7.
3. Lukianykhyn, V.A., Petrushenko, N.N. (2004). *Эkolohycheskyi menedzhment: pryntsypы y metodы* [Ecological management: principles and methods]. Sumы: Unyversytetskaia knyha.
4. Vashchenko, Yu. (1998). *Эffektyvnost orhanyzatsyy kak samotsel* [The effectiveness of the organization as an end in itself]. *Kompanon*, 5, 42-44.
5. Dehtiarova, I.B., Melnyk, O.I., Romanchenko, Ya.V. (2014). *Ekonomichni ta finansovi instrumenty zabezpechennia staloho rehionalnoho rozvytku: dosvid YeS* [Economic and financial instruments for sustainable regional development: the experience of the EU]. *Mechanism of Economic Regulation*, 3, 18-27.
6. Korotkov, Э.M. (1998). *Kontseptsyia menedzhmenta.* [The concept of management]. Moskva: Kompanyia «DeKA».
7. Melnyk. L. (1999). *Pryntsypy ekolohobezpechnoho rozvytku* [Principles of environmentally friendly development]. *Ekonomika Ukrainy*, 3, 71-79.
8. Morozov, Yu.P. (1997). *Ynnovatsyonnyi menedzhment* [Innovation management]. N. Novhorod: NNHU.
9. Herasymchuk, Z. (2000). *Naukovi osnovy doslidzhennia ekolohichnoi bezpeky yak faktoru stiikoho rozvytku* [Scientific bases of research of ecological safety as a factor of sustainable development]. *Ekonomika Ukrainy*, 11, 62-69.
10. Stadnytskyi, Yu. (2003). *Do problemy kontseptsii ekolohichnoi polityky Ukrainy ta mekhanizmu yii realizatsii* [To the problem of the concept of ecological policy of Ukraine and the mechanism of its realization]. *Ekonomika Ukrainy*, 1, 75-79.
11. Shcherbak, V. (2000). *Do kontseptsii vyrishennia resursno-ekolohichnoi problemy v Ukraini* [To the concept of solving the resource-ecological problem in Ukraine]. *Ekonomika Ukrainy*, 1, 51-54.
12. Maslovska, L. (2002). *Rehionalnyi aspekt transformatsii pryrodokorystuvannia v konteksti stiikoho rozvytku* [Regional aspect of nature transformation in the context of sustainable development]. *Ekonomika Ukrainy*, 2, 64-68.
13. Bilotserkivets, V.V. (2009). *Natsionalna ekonomika* [National Economy]. Kyiv: Tsentr uchbovoi literatury.
14. Vovk, V. (2009). Ekolohichna ekonomika yak suchasna intehralna nauka: vytoky ta zasadnychi pryntsypy [Ecological economics as a modern integrated science: origins and basic principles]. *Vidpovidalna ekonomika. Naukovo-populiarnyi almanakh*, 1, 33-47.
15. Maslov, D.H. (2005). Problemy vybora pokazatelei ustoichyvosty эkolohoэkonomycheskoi systemy rehyona [Problems of choosing indicators of stability of the ecological and economic system of the region]. *Vestnyk Moskovskoho un-ta. Seryia 6. Эkonomyka*, 6, 80-88.

16. Adámek, E., Kappel, S. (2015). Empirical Results for Some Monetary Areas According to Optimum Currency Area Criteria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensi*. 63 (3), 877-885.
17. Artis, M.J., Chouliarakis, G., Harischandra, P.K. (2011). Business Cycle Synchronization Since 1880. *The Manchester School*. 79 (2), 173- 207.
18. Kamarianakis, Y., Gallo, J. Le (2011). The Evolution of Regional Productivity Disparities in the European Union 1975-2000. *Regional Studies*. 45 (1), 123-139.
19. Kubatko, O. (2017). Economic Estimations of Pollution Related Cancer and Nerves Morbidity. *International Journal of Ecology & Development*. 32 (1), 33-43.
20. Veklych, O.O. (2012). *Pidvyshchennia diievosti vitchyznianoi systemy ekolohichnoho opodatkuvannia yak kliuchovoi skladovoi derzhavnoi ekolohichnoi polityky. Formuvannia ta realizatsiia natsionalnoi ekolohichnoi polityky [Improving the effectiveness of the domestic system of environmental taxation as a key component of state environmental policy. Formation and implementation of national environmental policy].* Sumy: Universytetska knyha.
21. Chumak, A.N., Yvanyenko, V.V. (2003). Ekoloho-экonomycheskye problemы sovremennosty [Ecological and economic problems of today]. Proceedings from: *Mizhnarodna naukovo-praktychna konferentsiia «Ukraina naukova 2003» – The International Scientific and Practical Conference «Scientific Ukraine 2003»*. (pp. 16-18). Dnipro: Nauka i osvita.
22. Marushevsky, G., & Hikman, D. (2017). «*Zelenyi» biznes dlia malykh i serednikh pidpryiemstv* [«Green» business for small and middle enterprises], Kyiv.
23. Natsionalna dopovid (2017). *Pro stan navkolyshnoho pryrodnoho seredovyshcha v Ukraini* [on the state of the natural environment of Ukraine], Kyiv, Ministry of Ecology and Nature. Resources of Ukraine.
24. Analytical reference (2018). Analiz vidpovidnosti ukrainskykh innovatsiinykh priorytetiv perspektyvnym svitovym naukovym ta tekhnolohichnym napriamam: sfera «Vodopostachannia, vodoochyshchennia, vodovidvedennia» [Analysis of compliance of Ukrainian innovation priorities with promising global scientific and technological areas: the field of «Water supply, water treatment, drainage»], Kyiv, Ukr INTEI.
25. Report of the Global Center for Digital Business Transformation. (2015). DigitalVortex. How Digital Disruption Is Redefining Industries. Retrieved from: https://www.cisco.com/c/dam/en/us/solutions/collateral/industry-solutions/digital-vortex-report.pdf.
26. Ansoff, I.H. (1993). *Strategic Management*. Moscow : Economy.

8.2. International scenarios for forecasting the development of a green economy in the blue world: management aspect

Liubov Kvasnii
Candidate of Economic Sciences, Associate Professor, Professor of Economics and Management, Ivan Franko Drohobych State Pedagogical University;
Professor of Management, organizations, economics and entrepreneurship, Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Drohobych -Truskavets, Ukraine
E-mail: lg_k@ukr.net
ORCID ID 0000-0001-5248-544X

Oksana Soltysyk
Candidate of Economic Sciences, Associate Professor, Associate Professor of Economics and Management, Ivan Franko Drohobych State Pedagogical University, Drohobych, Ukraine
E-mail: soltysik73@gmail.com

Svitlana Senyshyn
Director, Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine
E-mail: pimaup_doctorant@ukr.net,
ORCID ID 0000-0002-7905-3062

Olena Orlova
Candidate of Economic Sciences, Associate Professor, Professor of the Department of Law, Deputy Director of Academic Affairs, Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine
E-mail: olena.orlova54@gmail.com
ORCID ID 0000-0002-2145-2319

Yurii Shulzhyk
Ph.D., Professor of Management, organizations, economics and entrepreneurship, Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine;
E-mail: pimaup_ doctorant@ukr.net
ORCID ID 0000-0003-1699-054X

References to the greenhouse effect contained in the National Development Strategy 2020 are based primarily on the work of the International Panel on Climate Change (IPCC), established in 1988 by two United Nations organizations: the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to assess the risk of human impact on climate change.

Intergovernmental Panel on Climate Change on Climate Change, IPCC) is a group established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Program to assess scientific information on climate change and formulate realistic strategies for responding to it.

On August 9, 2021, the IPCC published the sixth report - on climate change as of 2021 and future risks to humanity for the next century. The complete document has almost 4 thousand pages, contains detailed forecasts for different regions of the Earth and is the product of the painstaking work of the best climatologists and other scientists from different countries [2]

The main documents published by the IPCC are the so-called Climate Change Assessment Report.

The main findings of the above report are:

- global climate change is a fact,
- the probability that these changes are caused by natural factors is about 5 %,
- the probability that these changes are caused by anthropogenic greenhouse gas emissions is more than 90%,
- it is predicted that the average global temperature in the 21st century will increase by 1.8-4 ° C; even an increase of 1.1-6.4 ° C is possible,
- there is a 90% probability that the frequency of severe weather events (eg heat, heavy rainfall) will increase.

Information based on research and the IPCC analysis shows that human activity accounts for 95% of the underlying cause of global warming, which we have seen for more than half a century.

IPCC reports are used in many countries, including the EU, to formulate national and international strategies and programs. climate change, and to study climate change. The IPCC is also the scientific basis for the process of the UN Framework Convention on Climate Change. The scale of recent changes in the climate system as a whole and the current state of its many aspects are unprecedented for many centuries and many millennia.

The report of the UN scientific group states that the concentration of carbon dioxide in the atmosphere in 2019 was the highest in the last 2 million years, and the global surface temperature "since 1970 has increased faster than any other fifty-year period in history for the last 2 thousand

Regarding other climate changes, the IPCC noted that the annual ice area in the Arctic between 2011 and 2020 was the lowest since 1850, and global sea levels have been rising faster since 1900 than in to any other century in the last 3,000 years. ” It is noted that the melting of ice and permafrost in the Arctic due to rising air temperatures, leads to the release of methane into the atmosphere, which contributes to global warming. due to rapid warming in the future, such temperature jumps will be observed more and more often. Researchers note that if environmental degradation continues at its current pace, the Maldives will disappear by 2100.

According to research by Ukrainian scientists, today is the day when Ukrainians have used more resources than the Ukrainian environment can recover in a year. Since August 8, Ukraine has been living in debt in nature. This date was calculated by researchers from the Global Footprint Network. Every year, experts analyze the use of natural resources in different countries and on the planet as a whole and determine the Day of Environmental Debt. For the whole Earth, it came on July 29.

Scientists around the world say that the resources of our planet are not limitless. By polluting water with toxic substances, littering the earth with plastic and chaotically extracting minerals, humanity is bringing the Earth closer to complete depletion.

"The only way out for humanity is to change the approach to resource consumption. To do this, each of us must reduce its environmental footprint - the amount of energy used, water and more. Simple habits, such as rational consumption of water and energy resources, reducing waste generation, applying the principle of minimalism when shopping, can save our future "

Scientists say that the concentration of carbon dioxide in the atmosphere in 2019 was the highest in the last 2 millions of years, and the global temperature of the earth's surface "has increased faster than any other fifty-year period in history over the past 2,000 years since 1970". Regarding other climate changes, the IPCC noted that the annual area ice in the Arctic between 2011 and 2020 was the lowest since 1850, and global sea levels "have risen faster since 1900 than in any other century in the last 3,000 years."

Human activity probably the cause of "melting glaciers across the earth over the past three decades, the melting of the giant ice sheet of Greenland, and the reduction of spring snow cover in North America. According to IPCC forecasts, the increase in global temperature will exceed the threshold set by the Paris Climate Agreement, "unless there is a sharp reduction in emissions of carbon dioxide and other greenhouse gases in the coming decades."

Scientists around the world say that in this case The planet will be threatened by extreme weather conditions, including droughts and floods, rising sea levels, and shrinking ice cover in the Arctic, to which many plants and animals will not be able to adapt. Thus, according to their forecasts, according to all the options considered, the global surface temperature will continue to rise, at least until the middle of this century.

According to the scenario of the highest emissions, global temperatures will rise by 5.7 degrees by the end of the century, and the lowest - by 2100, it may remain at 1 to 1.8 degrees compared to the pre-industrial era.

IPCC report created 234 experts from 66 countries, including Ukraine. The second and third parts of the report, which are expected to be released in 2022, will focus on the effects, adaptation and vulnerability to climate change, as well as efforts to mitigate the effects of human impact on the Earth's climate. Climate change was established in 1988 with the World Meteorological Organization and the United Nations Environment Program to assess scientific information on climate change and formulate realistic strategies to respond to it.

The World Meteorological Organization warns that our planet is waiting for " catastrophic "temperature rise". We are heading for a catastrophic 3-5 degree rise in this century. The 2015 Paris Climate Agreement, with which the United States withdrew, required participants to take steps to limit global warming to below 2 degrees Celsius. Celsius compared to the pre-industrial era.

Earth's deforestation has slowed over the past three decades, but about 420 million hectares of forest have been lost since 1990. According to the Food and Agriculture Organization (FAO), more than half of the world's forests are in five countries: the Russian Federation, Brazil, Canada, the United States and China. Experts from the World Wildlife Fund point out that there are 247 million hectares of pristine forests left in Russia that have not been touched by humans. But they are disappearing at a rate of more than 1.6 million hectares per year, and this rate is growing rapidly.

However, deforestation continues, which means that new areas of the planet will be deforested. In order to reverse deforestation and biodiversity loss, we need to review our production methods and consumption levels. food. Trees perform protective functions: they prevent erosion and soil loss and mitigate the effects of climate change. In addition, forests provide people with fuel and food. For many, they are an important source of income. According to Ukrinform, at the end of December 2020, an ozone hole closed over Antarctica, which was one of the largest and deepest holes in 40 years of observations.

The concept of the green economy arose in response to the global economic crisis, which began with the crisis in global financial markets in the second half of 2008 and turned it into the most serious economic and social crisis in 80 years. The scale of this crisis has not only revealed shortcomings in the regulation of financial markets, which are dangerous for the economy, but also confirmed the importance of structural reforms in the economy. In the international discussion of anti-crisis measures, it was stressed that they should create an opportunity to improve the functioning of the economy in the long run, while supporting the process of redirecting the economy to the so-called.

There is no generally accepted definition of a green economy (there is also the term "green growth", which is closely related to the green economy and is often equated with it). On the other hand, there are working definitions formulated by various institutions / organizations in connection with the developed tools and programs (UNEP, World Bank, OECD, European Commission). For its flagship Green Economy Initiative, the United Nations Environment Program (UNEP) is designed to define the green economy as one that improves human well-being and social justice while significantly reducing pressure on the environment and its resources. In its work, the OECD refers to green growth and defines it as changing patterns of production and consumption in order to reduce environmental pressures in a cost-effective way. A common starting point for these concepts is the realization that the current model of economic development cannot be strong pressure on the environment and its resources due to their limitations.

Therefore, the green economy is a new tool for achieving the SDGs, not an alternative paradigm of development. The so-called greening of the economy is considered at many levels and covers a number of narrower issues, such as the development of modern clean technologies, renewable energy, energy and material efficiency, changing the pattern of consumption and production to a more sustainable, integrated product policy, environmental public procurement. labor reform or environmental tax. The sectoral approach to the formation and implementation of the green economy / green growth also leads to the creation of a "green" nomenclature for, for example, jobs, energy, finance, transport, cities, etc. (green jobs, green energy, green financing, ecological transport, ecological cities, etc.). UNIDO (United Nations Industrial Development Organization), in turn, has developed a concept of "green industry" focused on the transformation (greening) of the industrial sector through more efficient use of raw materials to more intensively promote sustainable industrial development. Therefore, this is a sectoral strategy for implementing a green economy. Many international organizations' forums are working on definitions of terms under the Green Nomenclature, for example, the ILO (International Labor Organization) has recently introduced a definition of green jobs, and the OECD is working on indicators to monitor green growth. An international organization, focusing exclusively on green growth, the Global Institute for Green Growth, has also been established.

As in the case of the definition of a "green economy", there is no single set of rules, policies and measures that would constitute a common "green economy policy" that could be implemented at the national level. This necessary flexibility (according to the principle of "one for all") is emphasized in the outcome document of the United Nations Conference on Sustainable Development (Rio + 20), held in June 2012. In Rio de Janeiro, 20 years after organized in June 1992, the Earth Summit, during which the idea and principles of sustainable development were agreed and adopted in a binding manner. The Future We Want (FWW) recognizes the green economy as an important tool for sustainable development, while emphasizing that it provides policy options rather than a rigid set of rules.

The tools to transform the economy into so-called ecological paths should be adapted to the level of economic development of individual countries, so that green growth does not occur at the expense of less technologically advanced countries. In practice, at the national level, this justified and necessary flexibility in the approach to environmental decisions can also lead to uncertainty about what constitutes action in a green economy and which of the existing national instruments is implemented in the framework of sustainable development policy, climate change, and environmental protection. etc. can be considered a new, "green" quality. All of these factors - the need for flexibility with possible ambivalence and the reluctance of developing countries to agree and take global action on the green economy - have led to the international development of a tool for sustainable development, the green economy, largely through the collection and exchange of best practices. , indicative solutions (best practices, toolkits). FWW directly calls on the UN system, in coordination with donors and international organizations, to collect information on existing models, good examples, practices, policy evaluation methodologies, etc. in the field of green economy. collect information on existing models, good examples, practices, policy evaluation methodologies, etc. in the field of green economy.

This approach is also a constructive method of gaining public recognition for actions taken in the context of different situations in individual countries, which leads to more or less support for the "greening" of the economy and incurs the corresponding costs. The transition to a green economy is not possible through politics alone, but requires the involvement of business and the social partners. in particular, guaranteeing a high quality of life for present and future generations at the level allowed by the development of civilization, and at the same time efficient and rational use of available resources.

The main components of a low-emission environmental economy include:

- reconciling the improvement of economic performance while limiting the use of resources (including energy, water and mineral resources) and reducing the negative impact on the environment (disconnection); }} - perception of waste as a source of resources (for example, replacement of primary raw materials with secondary raw materials derived from waste), including:
- the desire to maximize waste as raw materials,
- optimization of supply chains,
- focus on reducing waste generation,
- the desire to close the cycles of raw materials, including maximum water and energy savings;
- design of technological solutions;
- support for energy efficiency and energy production from low-carbon sources with maximum use of local resource base;
- low-emission transport,
- energy-efficient construction,
- spatial planning and infrastructure investment, taking into account the need to adapt to climate change.

There are currently several definitions of green jobs in policy at the EU and other international organizations, and there has been a discussion for several years about standardizing this concept (or a similar term, ie green-collar workers). {1999} In 1999, in the context of green jobs, the OECD and Eurostat proposed activities that promote the creation of goods and services to quantify, prevent, limit, minimize or eliminate environmental pollution. damage related to water, air and soil, as well as activities related to waste, noise and ecosystems [1]. Applying this definition, it was estimated that 2) 2% of employees held green positions in 2009.

Differences in definitions may lead to differences in the statistics of these vacancies. Initially, the category of green jobs was mainly related to areas related to the protection of biodiversity and the environment, but now it covers other areas, such as technological innovation (especially eco-innovation), energy efficiency and resource efficiency.

The European Commission uses a broader definition than proposed by the OECD and Eurostat, and extends it to jobs related to the introduction of environmental technologies and products, where the basis should be environmental protection or resource management [6]. The development of environmental technologies in recent years has shown that investing in green growth offers great economic opportunities, as the EU eco-industry generates an annual turnover of 227 billion euros (2.2% of EU GDP) and currently creates 3.4 million jobs. [4]

In the years before the economic crisis (2004-2008), about 600,000 additional jobs were created in this area, and since 2000, the organic industry has grown by 7% [5]. }} The European Commission estimates that around one million new green jobs have been created in the EU in recent years, and that global turnover in the green technology sector is expected to triple by 2030 to reach € 3 trillion [5]. In Germany, the sector now accounts for about 8% of GDP and is expected to grow to 14% by 2020. In Austria, 4.8% of all workers work in the green jobs sector, an increase of 0.6% between 2010 and 2011 6) despite the ongoing crisis. In Poland, the environmental industry in 2007 created about 2% of jobs (compared to the general level of employment) [5].

Despite the existing ambiguities regarding the definition and system of skilled jobs as environmentally friendly, it should be assumed that changes towards a low-emission economy and an energy-efficient economy are and will be an increasing impetus for a significant increase in employment in green sectors of the economy.

Replacing obsolete technologies with solutions that use resources more efficiently, reduce environmental pressures and reduce emissions, create the need to train qualified personnel and create jobs with high environmental standards. In order to meet these expectations, the Ministry of Environment and the Ministry of Economy in the prepared integrated strategy "Energy Security and Environment - Perspectives to 2020" indicate measures aimed at creating green jobs that can be coordinated at the state level (the Ministry plays a leading role here). economy).

The document envisages:

- preparation of a proposal for a system of financial and fiscal incentives to create green jobs,
- increasing demand in the labor market for specialists in the field of environmental protection. The summit on the occasion of the 5th anniversary of the signing of the Paris Climate Agreement stated: “In Paris, we have promised to stop the temperature rise at 1.5 degrees. We have not made enough commitments to achieve this, even these promises are not being fulfilled. The level of carbon dioxide is record high. If we do not change course, we will face a catastrophic rise in temperature by more than 3 degrees this century. " Already 38 countries have declared a state of emergency, and now everyone else must do so by developing low-carbon energy. To reduce carbon emissions in the world by 45% by 2030 (compared to 2010) and, accordingly, to stop the rise in temperature at 1.5 degrees, a number of steps have been proposed:

- set the price of carbon;
- phase out funding and provide benefits for fossil fuels;
- stop building new coal-fired power plants;
- forcing to pay for carbon emissions of pollutants, not all taxpayers;
- be sure to disclose financial losses due to climate change;
- prescribe the need to achieve carbon neutrality in official documents.

As you know, the Paris Climate Agreement in 2015 was signed by more than 190 countries, including Ukraine. The purpose of the agreement is to prevent the average world temperature from rising by more than 1.5 degrees Celsius. After all, exceeding this temperature limit will directly lead to dangerous consequences. For example, to raising the level of the oceans and flooding of coastal cities, as well as to reduce the areas suitable for agriculture. The British energy market regulator Ofgem has approved the allocation of 30 billion pounds ($ 40 billion) to companies to modernize energy infrastructure in 2021-2026 to move to a cleaner and more reliable energy system. It is noted that this amount is 20% higher than the maximum amount of investment planned from the beginning.

Given the above, we can not talk about any procedure for creating green jobs. Their formation occurs as a result of socio-economic processes associated with the adopted strategic directions of development, both nationally, regionally and locally. Green transformation in the blue world should benefit all EU member states, as it focuses on economic growth, a cleaner environment and better public health.

In fact, the Green Agreement is a growth strategy for the whole EU. The EU countries will achieve the 2030 climate goals on the basis of solidarity, taking into account the differences between the different member states in the starting positions and in the structure of energy supply.

The European Council at prices that are affordable for households and companies, and with respect for the right of member states to determine their own energy balance and choose acceptable technologies to jointly achieve the 2030 climate goals, including transitional technologies such as natural gas. The EU Green Agreement provides for several areas of "green transformation", including technological development of industry, innovative approaches to reducing emissions, energy efficiency, the introduction of a circular economy, the search for renewable and new energy sources, such as hydrogen technologies, which will be an alternative to traditional carbon. natural resources.

According to the United Nations, 1% of the world's richest people have about twice as much carbon emissions as 50% of the poorest. In particular, the 10% of the richest people in the world use about 45% of all energy consumed for land transport and about 75% of all energy for aviation, compared to 10% and 5% respectively, which are used by 50% of the world's poorest households.

Thus, the richest people on the planet need to reduce carbon emissions as soon as possible to avoid dangerous warming in this century. To meet the goals of the Paris Agreement, the rich will need to reduce all indicators by 30 times. Although carbon emissions will fall by about 7% this year due to a pandemic, this will help reduce warming by only 0.01 ° C by 2050.

Researchers estimate that up to 92% of glaciers in the Alps could be lost by the end of the century due to climate change. Researchers at the University of Aberystwyth estimate that up to 92% of glaciers in the Alps could be lost by the end of the century due to climate change.

The 4,000 glaciers of the ridge include popular ski resorts such as Zermatt in Switzerland and Shadow in France. New Zealand has become the 33rd country to declare a climate change, along with Japan, Canada, France, the United Kingdom and other countries.

More than half of Ukrainians are aware of the threats and disasters posed by climate change. Climate change is now dangerous and threatens not only our generation but everyone else. And the main reason is the burning of oil, gas and coal.

We have only been doing this for 200 years, but we cannot make important international instruments that induce solutions to these problems work. In particular, the Paris Agreement, which was adopted in 2015, and complex political processes do not allow even after the official entry into force of this agreement, to effectively implement its measures and keep the level of global warming at 0.5 degrees. The solution to this problem is very complex, complex and does not lie in only one plane. This requires not only political, but also legal, organizational, social, economic approach. And this is now considered the European green course in the blue world.

REFERENCES

1. Definition of green jobs in English: activities that produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. 1999, OECD / EUROSTAT, Luxembourg.

2. OECD employment prospects 2012, 2012, Paris.

3. Facts and figures of the links between the EU economy and the environment, 2007, European Commission, Belgium.

4. Number of jobs that depend on improving the environment and resource efficiency, 2012, ECORYS / DG Envi, Belgium.

5. EU environmental policy that supports jobs and growth, 2011, European Commission, Belgium.

6. Draft report on eco-innovation - job creation and growth through environmental policy, (2012/2294 (INI)), European Parliament, Belgium.

8.3. Global eco-strategies of manufacturing companies

Sabadash Vira

Doctor of Sciences (Technical sciences),

Professor of department of ecology and sustainable environmental management

Lviv Polytechnic National University

E-mail: virasabadash@gmail.com

ORCID ID 0000-0002-6091-4053

Adapting to the requirements of the European Union in the context of environmental protection is still a difficult task for Ukraine. This is largely due to the coherence of many sectors of the economy, as well as the need for long-term involvement of various government agencies and companies. The reflection of the strategy of efficient use of nature and natural resources in the Slovak region from the beginning of the early period is based on balanced development, environmental policy and the Global Program of Action - Agenda adopted at the conference in Rio de Janeiro in 1992, as well as major international organizations community in 1994. These statements should be effectively stimulated by various forms of administrative self-government and taken into account in the global environmental policy of enterprises. Practice has shown that environmental policy is best implemented and enforced, primarily through economic and legal instruments and, to a lesser extent, through the intervention of foreign instruments.

Modern enterprises are faced with changing conditions for the management of a la carte, consisting of a number of processes, mostly global in nature. These are, in particular, unification of standards, homogenization of consumer behavior, liberalization of trade in the international dimension progress in the field of computerization and transformation to the information society and knowledge-based economy. These changes are accompanied by the gradual degradation of the natural environment. which creates various barriers to economic development [i].

This leads to changes in the management systems of the organization. One of the directions of these changes is to draw attention to the environmental context of management and - more broadly - to the need to form environmental awareness and implement the idea of sustainable development in the functioning of modern enterprises. The catalyst for these changes should be environmental innovations, which can be understood as changes in technology, organizational structure and management of the enterprise, which reduce or prevent the negative impact on the environment. Innovations should be implemented systematically, combined with strategic and operational activities of the enterprise and their others obeyed and controlled decision-makers. Therefore, we can talk about the management of environmental innovations, both in a narrower context, referring to the level of the enterprise organization, and in a broader dimension - considered at the level of regional, national and international programs [ii].

With this in mind, the presentation of the basic assumptions for the management of environmental innovations in a modern enterprise is a subject that allows you to create, implement and disseminate environmental innovations in the organization on the principles of sustainable development.

Characteristics and types of ecological innovations

Eco-innovation (eco-innovation) is the same complex and multidimensional phenomenon as other types of innovation. The starting point for their definition can be the classic considerations in this regard, J. Schumpter, who emphasized the technical, economic and organizational context of innovation. emphasizing at the same time the functional meaning of this term. On the other hand, the Oslo Handbook defines innovation based on management as the introduction of a new or significantly improved product or process. a new organizational method or marketing in economic practice, organization of work or relations with the environment. However, the definitions of tc describe innovations in general and do not allow a clear distinction between eco-innovations [iii].

It seems that to define iconological innovations it is necessary to pay attention to the scope and purpose of the context of this concept. Innovations are introduced to create or modify processes, products, techniques or actions that are perceived by the company as new and progressive in the field and lead to increased efficiency in the use of resources at its disposal. Environmental initiatives can be called a legacy of environmental innovation at the enterprise level. which, at the same time, fit into the concept of sustainable development [iv].

On the other hand, the focused context of eco-innovation appears, in particular, in the Oslo Handbook [v], which draws attention to the fact that the introduction of innovations in products, processes and organizational innovations may limit environmental impact or improve health. and security. From a legal point of view, taking into account the target context, other environmental innovations have been identified for the Competitiveness and Innovation Framework Program. At this level, they are considered all forms of innovation that lead to significant visible progress towards the goal of sustainable development, limiting the impact on the environment or achieving greater efficiency and responsibility for reducing the use of resources, including energy [vi].

Therefore, this definition focuses primarily on the attributive meaning of the concept of innovation, which is seen as the company's response to specific social needs and the economy associated with the implementation of the concept of sustainable development and environmental progress. The ecological strategies of enterprise development presented in the literature define sustainable development, which is a concept that emphasizes the interdependence of environmental, economic, social and spatial inflows in socio-economic development and the need to conserve resources for future generations. The importance of this philosophy was stated both in the Constitution of Ukraine and is a constitutional principle of the development of the European Union. At the enterprise level, this idea can be implemented in the form of a sustainable development strategy can be seen as a tool to support the implementation of sustainable development strategies [vii], as shown in Fig. 84.

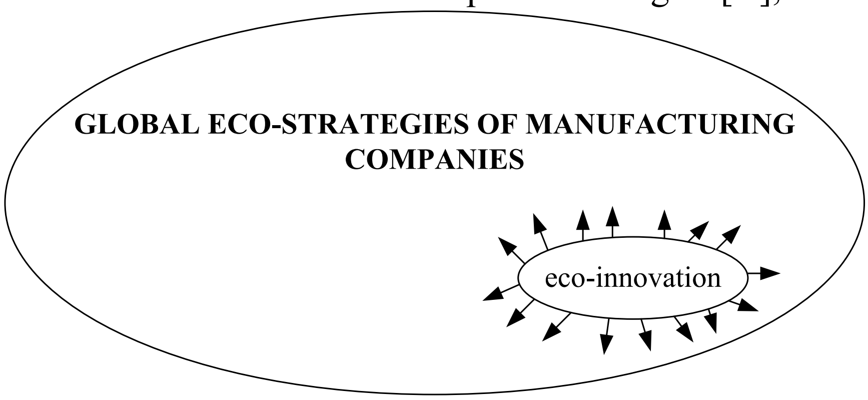


Figure 84. The scheme of implementation of eco-innovations at the enterprise level

Source: Own research

Eco-innovation at the enterprise level is seen as a reduction or increase in the negative effects of the company on the environment.

Ecological innovations, as an important theoretical category, can be systematized taking into account various criteria. In particular, we can list the following eco-innovations [viii]:

- eco-innovation of products. which consists in the introduction of products or services in the field of ecology, which allows to implement; environmental goals that are new or significantly improved at the end of their functions or applications. Examples are the replacement of production facilities with materials with improved properties (eg environmentally friendly plastics, etc.), the introduction of products with a significant reduction in energy consumption (energy-saving refrigerators, etc.), significant changes to products related to their adaptation to environmental standards.

Process eco-innovation which consists in the introduction of a new or significant improvement in the melody of production or delivery, which satisfies the scope and purposeful krill, associated with environmental protection and environmental development. An example is the installation of new or improved production technology that reduces the negative impact on the environment, organizational eco-innovations. which means the introduction of a new organizational method in the principles of operation adopted by the company, in the organization and in the workplace or in relations with the environment, related to the development of circological consciousness and ability to perform tasks related to environmental development and sustainable development. An example is the creation of formal or informal working groups for the first implementation of tasks related to environmental activities. or implementation of an environmental management system (eg ISO scrii 14000) marketing eco-innovations which are the introduction of a new marketing method that involves significant changes in the design / structure of the product or packaging dissemination, promotion with special emphasis on environmental principles or formation environmental awareness as part of current PR activities [ix]. An example is the introduction of a fundamentally new packaging design based on environmentally friendly solutions.

The fact of financing innovation from external sources, including funds from the European Union, has also become important here.

Further classification of eco-innovations can be made on the basis of other criteria, such as: the extent of their impact, the consequences of the application of innovations in the organization and economy, technological and capital intensity. strict understanding and others. Eco-innovation is a concept that develops in accordance with the current state of knowledge in the field of environmental protection and ecology and with specific goals set for enterprises, as well as governmental and international programs and strategies that support environmental protection and sustainable development [x].

The introduction of environmental innovations, including changes in technology and production technologies that reduce the negative impact of production processes on the environment, is one of the activities that supports the greening of management. Its source is largely environmental awareness, implemented through a number of measures implemented at the enterprise level, which leads to improved environmental parameters of the organization, and therefore to take into account the postulate of environmental protection in all areas of activity.

An element of the process of environmental innovation management

Eco-innovators aim to develop new Class 6 products in processes that provide value to both the consumer and the business and significantly reduce the negative impact on the environment. They are considered an innovative system consisting of new ones that avoids or reduce harmfulness to the environment or achieve higher environmental performance [[xi]].

Classical definitions of management, describing its essence, relate to certain elements of this phenomenon, such as:

- management strategy,
- management functions.
- subject (object) of management.
- business entities.
- tools and instruments used in the management process - the effects that management should achieve.

Innovation management (innovation activity) can be understood as an ordered set of activities from a functional point of view (planning and taking measures, organization, management and control). focus on the resources of the organization (human, financial, tangible and intangible, including information). to achieve the planned goals of the organization in the field: the choice of methods, technologies and organizations, the acquisition of knowledge and innovation and their effective and efficient application, adhering to the principles of the concept of sustainable development. Management of ecological innovations at the enterprise level is a subdiscipline and concretization of innovative activity in the field of ecology and ecologically clear activity carried out by the organizations.

The goals of eco-innovation management can be considered at different levels: strategic, tactical or operational. From a general point of view, these goals can be ecological, economic, socio-technical and production. Selected goals of eco-innovation management include:

- reduction, prevention or elimination of the negative impact of the enterprise on the natural environment,
- support for the implementation of sustainable development,
- improvement of economic results and efficiency of the carried out activity,
- improve the reputation of the company and its environment.

From a functional point of view, the environmental innovation management process includes planning and decision-making, organizing and providing resources to achieve goals, inspiring and motivating employees and management to create and implement innovative and environmental innovations, and measuring and evaluating the consequences of their implementation. A necessary condition for maintaining the continuity of the management function and the bodies that create it is the presence of a control object separated from the background, which is understood as an organization or part of it, and that the elements of this object respond to the impulses of the control center (subjects) . management) [xii].

Therefore, environmental innovation management can be this part of the organization.

The process of environmental innovation management should also take into account the requirements and initiatives of employees within the enterprise, as well as, some, the proposals of external consultants and deputies of the organization, including clients, local communities and environmental communities.

The availability and role of management entities vary depending on the characteristics of the organization. For example, in large enterprises, this role can be performed to varying degrees at different levels of the organizational hierarchy, while clearly distinguishing between organizational groups or processes responsible for pro-environmental innovation. In small companies, however, the management process focuses on the identity of the owner with possible collaboration with selected employees and / or external consultants [xiii].

In addition, it is important to keep in mind the need to separate the managerial role from the catalyst role performed by technical managers. The head of innovation combines the role of strategic management, organizational and technical expert. While the role of catalyst is played by an informal leader, who often decides on the staff of the team that creates innovations and the creator of the pro-innovation climate in the company [xiv].

Used tools and instruments that are an auxiliary element of environmental innovation management. Selected tools of environmental management in the organization include:

- environmental management systems, both in accordance with international standards, such as EMAS, ISO 14000 series, and on other bases, such as responsible care programs,
- conducting ecological (ecological) examination,
- environmental impact assessment (E1A),
- ecological design of the product life cycle (LCD or DFE),
- ecological balance (ecobalance),
-environmental assessment of sites and organizations (EASO),
- environmental audit,
- multicriteria methods of decision making,
- methods of modeling and modeling,
- heuristic methods.

The implications of eco-innovation management include, for example, reducing environmental damage and improving occupational safety and health, as well as complying with environmental rules, norms or standards. Other effects include: reducing operating costs and improving economic performance, improving safety and working conditions, increasing the company's value to investors, improving the organization's image in the eyes of stakeholders, including the public and pro-environmental communities, reducing the organization's diversity or increasing environmental performance. employee awareness and other effects [xv].

Approach to environmental protection and behavioral behavior of enterprises.

A static approach to environmental protection means that the company adopts a passive or reactive environmental strategy. The adoption of a passive environmental strategy (static approach) means "dilution" of pollutant emissions (controlled discharges). In accordance with the preconditions of the environmental policy of the state, enterprises, mainly industrial, are legally obliged to limit the negative impact of their activities on the natural (natural) environment. Entities that do not meet the minimum requirements for environmental protection demonstrate ignorance of environmental issues. This approach will subject the company to numerous fines for non-compliance with environmental law and increased environmental fees and taxes, which threatens its image and competitive position.

Developing a passive strategy is a reactive strategy. A company that has adopted a jet model and pays strategic attention to it operates in accordance with environmental standards only to the extent necessary, usually with the help of technology "at the end of the pipe" and the optimization of existing production processes. The end-of-pipe approach is a static model if the company adheres to acceptable environmental standards (emission limit values) and stops making further changes to improve the reduction of environmental impact. The reaction of the enterprise is usually technical, manifested, in particular, in the interest in the "end of the sewer pipe." Adoption of a reactive environmental strategy means low sensitivity of enterprises to the environmental requirements of the market, and strategic strategies are often defensive in nature - the board of companies believes that they are under siege of the law and are in a state of public opinion.

Some organizations anticipate future developments in the legal environment and take a proactive approach to the environment. You usually need to respond to an advance. The main role here is played by proactive strategies of enterprises related to environmental protection (proactive environmental strategies - PSS). They are part of a dynamic approach of enterprises to environmental protection, which, to meet the requirements of the environment, also becomes dynamic. The dominant driving force for achieving strategic activity of the enterprise is the impulse in the form of changes in legislation. Proactivity is a purposeful, situational and one-time activity.

Enterprises with a dynamic approach to environmental protection voluntarily strive for cleaner production, seek technological (technological and product) solutions and organizational solutions that will help prevent pollution "at its source" and provide a competitive advantage. It connects the technological sphere with the organization concerning aspects of the environment. This often unique interaction is made possible by the organizational resources and capabilities of the enterprise. These abilities, if we adopt an evolutionary model of strategy, manifest themselves with the increase of the emergency situation in the environment.

Enterprises that dynamically develop environmental programs that allow the external and internal environment of the enterprise to interact. This creates an interactive and dynamically proactive environmental strategy. It focuses on a creative and innovative approach and the development of sustainable environmental programs in corporate structures. A serious challenge for enterprises is not only technological, but also strategic and organizational reorientation to innovation and cooperation.

Proactive environmental strategies incorporate environmental issues into the practice of companies that use a systems approach. As mentioned earlier, a proactive environmental strategy is sometimes equated with a cleaner production strategy, which is a good start to effective design and implementation. However, companies that have adopted an active environmental strategy are less dependent on technological recommendations. Indeed, environmentally friendly technologies are evolving and improving. The difficulties are at the intersection of restrictive legal norms and rules of a market economy [[xvi]]. The international literature offers various definitions of the nature of the initiative ecologist.

In the Miles and Snow typology, enterprise strategies were identified based on the assumption that each organization makes its behavior dependent on finding solutions to three problems: administrative, entrepreneurial, and technological (engineering). With this approach, a proactive environmental strategy requires the effective integration of all these areas of the enterprise to obtain the intended results of development, and methods of solving problems by enterprises determine the direction of pro-environmental activities. Success in implementing a researcher's strategy depends on developing and maintaining the ability to analyze a wide range of changes in the environment. The strength of companies that implement a strategic researcher is the active analysis and filtering of market opportunities. In negative events, they can see opportunities and use them. A special skill of enterprises with a dynamic approach to environmental protection is to use threats in the legal environment as opportunities. The offensive nature of environmental strategy is also presented by J. Reps. Such an active environmental strategy is based on the use of both own and external funds needed to improve production processes to protect the environment. This type of strategy focuses on a systems approach and the creation of a pro-environmental organizational culture. It is based on the assumption that not only each employee, but also each stakeholder who makes up the staff within their activities (with competencies and abilities), is responsible for the implementation of tasks, goals and environmental strategies [[xvii]].

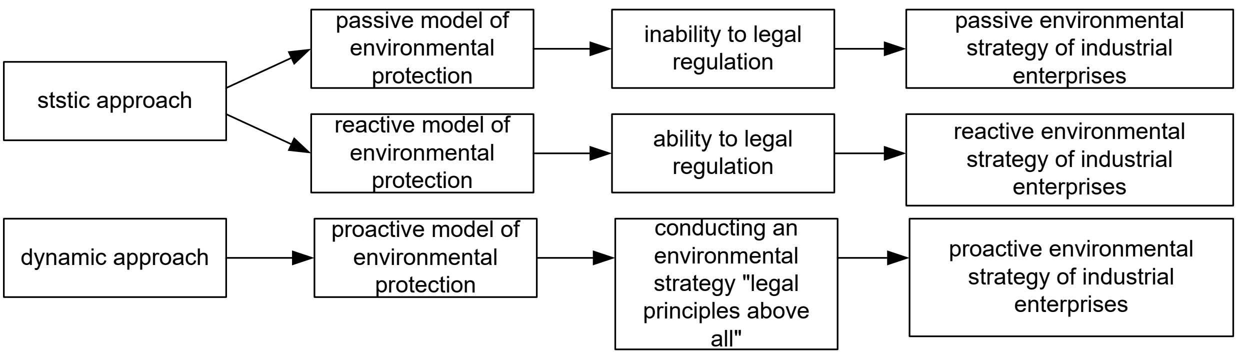


Figure 84. Global environmental strategies of enterprises and the evolution of approaches to environmental protection

Source: Developed by the authors based on Managing supply chain resilience to pursue business and environmental strategies (2020)

Strategy of adaptation of companies to changes in the context of global environmental risks

The activity of the organization is manifested not only in the ability to adapt to the turbulence of the environment. It is also, and perhaps most importantly, the ability and ease to initiate and create your own internal organizational change, not only to avoid threats to the environment, but also to make effective use of the opportunities that arise. Proactivity means the ability to shape the environment to a degree that exceeds the ability to shape the behavior of the environment. According to this logic of reasoning, we can distinguish two types of proactivity: external and internal in relation to the enterprise. External proactivity is the ability to actively (dynamically) influence the environment of the organization, which is based on a more "voluntary" approach of the enterprise to respond to changes in the environment. Internal proactivity means the ability of an organization to quickly adapt to environmental conditions (context), and this adaptation, as if "forced" under the influence of environmental factors, primarily related to changes in the provisions of environmental law.

Proactive action was much easier in a period when the environment was stable, and today, in principle, no longer occurs. Increasing variability of the environment means the emergence of dynamic and constant, but predictable changes. The emergence of a dynamic environment means the emergence of uncertainty, which leads to competition [[xviii]].

Dynamic approach and direction of preventive implementation of ecological strategy at the enterprise

Service activity means compliance with the law, in addition to the requirements of compliance with regulatory requirements for environmental protection (compliance plus), as well as the voluntary implementation of the company's environmental management systems in accordance with the basic principles of ISO 14001 or EMAS. Dynamic enterprises are excellent in terms of the environment and market requirements (commercial and natural environmental advantage) and use the assumptions of the concept of quality management - TQM (Total Quality Management), transforming it into the concept of TQEM (Total Quality Environmental Management). Emphasizing the role of practicing managers in solving environmental problems35. Enterprises with a proactive strategy conquer new markets, introduce new innovative products or production methods, seek new sources of supply and apply an environmentally friendly approach to raw materials and energy using the 3R concept (reduction, reuse, recycling) and actively interact with stakeholders. Focus on the implementation of environmental services (functional perspective) can be performed on the basis of the guidelines of ISO 14001 or EMAS and the concept of TQEM36. A cleaner production program is a good start (preparation for the implementation of an environmental management system in accordance with ISO 14001 or EMAS. J. Delgado-Sebalos and others lead the implementation of a proactive strategy for overall environmental quality management under the assumptions of the concept of environmental quality management). In the case of PSS implementation, the focus will be on economic savings, reduction and disposal of waste associated with the design, manufacture, use and disposal of products and materials. Environmental Initiatives srj component integrator) of the TQEM concept, where the zero defect strategy is consistent with strategic zero pollution. The basis for such targeting of a proactive environmental strategy is the recognition of pollution, regardless of its type and form, as a murder38. Loss of materials, energy or other resources proves the inefficiency of production. Stop) implementation and implementation of a proactive strategy will then be eco-efficiency59, identifying needs and customer satisfaction, a flawless approach, a proactive approach to solving problems. The TQEM concept recommends shifting the focus from control through control through control through environmental management. Implementation of a proactive strategy is aimed at meeting the needs of all customers and their expectations.

Nogg companies have also developed their own environmental programs tailored to individual needs. A significant problem for many companies is the lack of partners from the state to conclude agreements and support environmental initiatives.

Dynamic approach of enterprises to environmental protection in times of crisis

Active and reactive enterprises behave differently in times of crisis and market change. Emerging threats and opportunities as a result of destructive events give impetus to further action. An enterprise facing uncertainty tries to insure itself against economic risks in advance by planning an organized response to its expected manifestations. Proactive businesses are more resilient to alarming events, especially those related to the tightening of regulatory requirements for environmental protection. This resistance is the ability of an active enterprise to withstand systematic inequalities and adapt to environmental risks in order to formulate a strategy in the context of reducing the risk of working in uncertain environmental conditions. The trajectory of a proactive enterprise follows a cycle of adaptability that leads to adaptation and learning in the context of distorting events [[xix]].

Proactive companies in the field of environmental protection are more prone to activities associated with increased risk, and it is easier for them to cope with difficult conditions of change (sustainability). Sustainability allows not only to respond to a difficult situation, but also to actively learn and develop, accepting challenges. Sustainability is a hidden ability of active enterprises, built on the basis of social interaction and relations with stakeholders. This is felt when organizations are defeated. This ability of businesses to cope with difficult situations is of particular importance today and will be felt in the near future, due to the growing demands of climate change. By their very nature, enterprises with a dynamic approach to environmental protection are mainly pro-ecological, but also economic (including measures to renew capital). After all, risk is a trait associated with innovation. Most innovations are tied to economic, technical or market risk. Risk-taking and courage are one of the dimensions of proactivity, along with entrepreneurship and innovation.

A proactive enterprise uses uncertainty, making it the most important resource for innovation and eco-innovation. An active approach of enterprises to environmental protection requires new solutions characterized by entrepreneurship (environmental).

It is necessary to move towards the application of more flexible pro-environmental solutions, especially in the field of strategy formulation. The company itself must make all changes as soon as possible, allowing it to adapt to changing environmental standards earlier than its competitors [xx]. If a proactive environmental strategy is adopted, it is necessary to provide continuous training for staff which will systematically analyze the environment and, above all, monitor the legal environment. Monitoring allows you to predict the most likely changes in legislation. Change is the main tool for creating competitive advantage.

Changes in management, combined with increased attention to environmental issues, are forcing modern enterprises to implement environmental management strategies and implement environmental innovations. At the same time, eco-innovators are a special subgroup of innovations implemented in organizations that differ in activities and goals. In the management of the category of initiatives at the enterprise level, there are various elements that affect the productivity and effectiveness of the actions implemented. The results of accident research show that the introduction of environmental innovations can bring special benefits, both economic and environmental and others. On the other hand, the results of statistical analysis show that entrepreneurs are not aware of the importance of the effects created by eco-innovation. There is a need for the constant development of environmental awareness both among those who directly manage environmental innovations and shape the environmental activities of enterprises, as well as among employees or local governments. As a result of change and development, this awareness will lead to internal stimulation of the need to implement environmental innovations by economic entities.

REFERENCES

i. Reis, G. G., Heidemann, M. S., Matos, K. H. O. D., & Molento, C. F. M. (2020). Cell-Based Meat and Firms' Environmental Strategies: New Rationales as per Available Literature. *Sustainability*, 12(22), 9418. **DOI: 10.3390/su12229418**

ii. Klingelhöfer, D., Braun, M., Quarcoo, D., Brüggmann, D., & Groneberg, D. A. (2020). Research landscape of a global environmental challenge: microplastics. *Water research*, 170, 115358. **DOI: 10.1016/j.watres.2019.115358**

iii. Radu, C., Caron, M. A., & Arroyo, P. (2020). Integration of carbon and environmental strategies within corporate disclosures. *Journal of cleaner Production*, *244*, 118681. **DOI: 10.1016/j.jclepro.2019.118681**

iv. Mitchell, R. B., Andonova, L. B., Axelrod, M., Balsiger, J., Bernauer, T., Green, J. F., ... & Morin, J. F. (2020). What we know (and could know) about international environmental agreements. *Global Environmental Politics*, *20*(1), 103-121. **DOI: 10.1162/glep_a_00544**

v. Ramón-Jaramillo, S., Sarango-Lalangui, P., Campoverde-Romero, A., & Torres-Zambrano, J. (2017, June). The use of the Oslo handbook in innovative and technological business initiatives. Case: Business initiative Center Prendho ecuador. *In 2017 12th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-6). IEEE*. **DOI: 10.23919/CISTI.2017.7975875**

vi. Aragon-Correa, J. A., Marcus, A. A., & Vogel, D. (2020). The effects of mandatory and voluntary regulatory pressures on firms' environmental strategies: A review and recommendations for future research. *Academy of Management Annals,* 14(1), 339-365. **DOI: 10.5465/annals.2018.0014**

vii. Maggi, F., la Cecilia, D., Tang, F. H., & McBratney, A. (2020). The global environmental hazard of glyphosate use. *Science of the Total Environment*, *717*, 137167. **DOI: 10.1016/j.scitotenv.2020.137167**

viii. Mirzekhanova, Z. G. (2021). Regional Environmental Programs: Problems of Implementation. *Geography and Natural Resources*, *42*(2), 99-106. **DOI: 10.1134/S1875372821020098**

ix. Günther, S. A., Staake, T., Schöb, S., & Tiefenbeck, V. (2020). The behavioral response to a corporate carbon offset program: A field experiment on adverse effects and mitigation strategies. *Global Environmental Change*, *64*, 102123. **DOI: 10.1016/j.gloenvcha.2020.102123**

x. Asgary, A., Ozdemir, A. I., & Özyürek, H. (2020). Small and medium enterprises and global risks: evidence from manufacturing SMEs in Turkey. *International Journal of Disaster Risk Science*, *11*(1), 59-73. **DOI: 10.1007/s13753-020-00247-0**

xi. Umadia Sr, K., & Kasztelnik, K. (2020). The Financial Innovative Business Strategies of Small to Medium Scale Enterprises in Developing Country and Influence for the Global Economy Performance. **DOI: 10. 123456789/80738**

xii. Naradda Gamage, S. K., Ekanayake, E. M. S., Abeyrathne, G. A. K. N. J., Prasanna, R. P. I. R., Jayasundara, J. M. S. B., & Rajapakshe, P. S. K. (2020). A review of global challenges and survival strategies of small and medium enterprises (SMEs). *Economies*, *8*(4), 79. **DOI: 10.3390/economies8040079**

xiii. Repnikova, V. M., Bykova, O. N., Stroev, P. V., Morkovkin, D. E., & Kurbakova, S. N. (2020). Improvement of approaches to the strategic development management of enterprise. *Entrepreneurship and Sustainability Issues*, *8*(1), 301. **DOI: 10.9770/jesi.2020.8.1(21)**

xiv. Zheng, S., He, C., Hsu, S. C., Sarkis, J., & Chen, J. H. (2020). Corporate environmental performance prediction in China: An empirical study of energy service companies. *Journal of Cleaner Production*, *266*, 121395. **DOI: 10.1016/j.jclepro.2020.121395**

xv. Bartolacci, F., Caputo, A., & Soverchia, M. (2020). Sustainability and financial performance of small and medium sized enterprises: A bibliometric and systematic literature review. *Business Strategy and the Environment*, *29*(3), 1297-1309. **DOI: 10.1002/bse.2434**

xvi. Liou, R. S., & Rao-Nicholson, R. (2021). Multinational enterprises and Sustainable Development Goals: A foreign subsidiary perspective on tackling wicked problems. *Journal of International Business Policy*, *4*(1), 136-151.. **DOI: 10.1057/s42214-020-00080-8**

xvii Centobelli, P., Cerchione, R., & Ertz, M. (2020). Managing supply chain resilience to pursue business and environmental strategies. Business Strategy and the Environment, 29(3), 1215-1246. **DOI: 10.1002/bse.2428**

xviii. Richnák, P., & Gubová, K. (2021). Green and reverse logistics in conditions of sustainable development in enterprises in slovakia. *Sustainability*, *13*(2), 581. **DOI: 10.3390/su13020581**

xix. Rispoli, G., & Olšáková, D. (2020). Science and Diplomacy around the Earth: From the Man and Biosphere Programme to the International Geosphere-Biosphere Programme. *Historical Studies in the Natural Sciences*, *50*(4), 456-481. **DOI: 10.1525/hsns.2020.50.4.456**

xx. Ndubisi, N. O., Zhai, X. A., & Lai, K. H. (2020). Small and medium manufacturing enterprises and Asia's sustainable economic development. *International Journal of Production Economics*, 107971. **DOI: 10.1016/j.ijpe.2020.107971**

8.4. Investing in the development and implementation of «clean» technologies

Olha Misechko
Professor, EdD in Theory and Methodology of Professional Training,
PhD in Theory and History of Pedagogy,
Ivan Franko National University of Lviv
E-mail: o.misechko12@gmail.com
ORCID ID 0000-0002-6425-1322

Khrystuna Podvirna
Candidate of Sciences (Geography),
Associate Professor of department of international economic and investment activities,
Ivan Franko National University of Lviv
E-mail: hrystyna.podvirna@lnu.edu.ua
ORCID ID 0000-0002-0828-9078

In the context of exacerbation of economic and environmental problems in recent decades, countries around the world are focusing their efforts on promoting environmental improvement as a new source of further development. Intensifying these activities can help accelerate progress towards sustainable development and poverty reduction through, for example, more sustainable use of natural resources, energy efficiency and the provision of ecosystem services. In recent years, in terms of implementing a strategy of environmentally oriented growth, economically developed countries are rapidly introducing "clean" technologies. The above determines the relevance of the definition of investment in the development and implementation of "clean" technologies and indicates the need to clarify the prospects and tools to promote the effective functioning of the global market for "clean" technologies as an effective mechanism for climate change and sustainable economic development.

Over the past 20 years, an important condition for the accelerated progress of socio-economic development of most countries has appeared in the form of an effective policy of innovations actions with the ultimate goal to implement novelties in engineering, technology, labor organization and management, based on scientific achievements and technical progress. Achieving of long-term goals is significantly facilitated directly by technological innovations, which expand the range of available options and potential strategies to reach them, alongside reducing over time the cost of their implementation. In reality, innovations are more complex, and only a small proportion of technologies "follow" a smooth transition from one stage to another, because this approach is not able to cover all aspects and conditions that may arise during the implementation of the whole process. In addition, a particular technology may be successful in one country, but may be not in line with general market realities or not suitable for other countries, which will require changes at any of the stages.

Without a major acceleration in clean energy innovation, net-zero emissions targets will not be achievable. The world has seen a proliferating number of pledges by numerous governments and companies to reach net-zero carbon dioxide ($CO2$) emissions in the coming decades as part of global efforts to meet long-term sustainability goals, such as the Paris Agreement on climate change. But there is a stark disconnect between these high-profile pledges and the current state of clean energy technology. While the technologies in use today can deliver a large amount of the emissions reductions called for by these goals, they are insufficient on their own to bring the world to net zero while ensuring energy systems remain secure – even with much stronger policies supporting them.

Energy efficiency and renewables are fundamental for achieving climate goals, but there are large portions of emissions that will require the use of other technologies. Much of these emissions come from sectors where the technology options for reducing them are limited – such as shipping, trucks, aviation and heavy industries like steel, cement and chemicals. Decarbonising these sectors will largely demand the development of new technologies not yet in use. And many of the clean energy technologies available today need more work to bring down costs and accelerate deployment.

Innovation is the key to fostering new technologies and advancing existing ones.

The concept of investing in "clean" technologies is quite new for domestic science and practice. It is worth noting that, despite the use of this term in the Western scientific literature, the interpretation of the essential content of this category in domestic science is practically absent.

One of the most important principles of investing in "clean" technologies is the principle of strategic policy orientation. The actions of all entities (government, private market entities , both financial and non-financial, non-governmental non-profit organizations, households, etc.) should be aimed at achieving long-term development goals. Strategic orientation at the level of the country's economy in general can not be formed solely on the basis of situational market actions, because the free market is mostly focused on goals that can bring profits in the short or medium term. Due to the high level of uncertainty about investing in long-term projects, as well as the significant conditionality of future income from such investments by the level of development of economic regulation institutions, the state has a key role in forming new financial mechanisms, instruments and individual capital market segments. As a result, the issue of investment, which is aimed at achieving strategically important goals for the country, is extremely important for the state. It significantly influences the process of creating a national system for attracting and distributing investment capital. This impact is associated with the development of a set of clear and natural measures of regulatory policy to promote investment in "clean" technologies through various financial instruments [6]. Regulatory measures not only stimulate the overall capital growth of "clean" technologies (including through its imports), but also provide their most profitable, from the standpoint of national economic interests, interfield and intersectoral location. An important principle of the policy of investing in "clean" technologies is the interaction of the state and business in solving the key goals of sustainable development. Financing the transition to "clean" technologies far exceeds the capabilities of the public sector in any country in the world, and even more so in Ukraine. Large investments require significant private sources of funding. Moreover, the introduction of fundamentally new approaches and mechanisms in the practice of economic development requires ensuring a high level of cooperation between various entities - the state and private financial institutions, financial regulators and supervisors, various business associations and unions, international economic and financial organizations involved in creation of appropriate standards and regulations, as well as business platforms and initiatives.

Closely related to the above is the principle of corporate social responsibility, without which it is impossible for business to interact with the state effectively and socially usefully. This principle is based on the construction of an individual strategy for business development and corporate governance in Ukraine.

Another important principle is the principle of broad international cooperation in the sphere of investing in "clean" technologies and the development of a national system of legal regulation of this process in close coordination and consistency with the development of appropriate mechanisms in the world and Europe.

In addition, the principle of taking into account the national specifics of the development is extremely significant. It is determined by not only the historical path of the country the level of its socio-economic development, the profile of its competitive advantages as compared to other countries, but also its cultural peculiarities. As far as there is no single model of investment policy that could be used by all countries of the world, for each country such a policy is specific. Although the basic set of elements for an integrated policy of investing in "clean" technologies is likely to be the same for the vast majority of countries, such a policy should be developed according to national priorities and adapted to the unique national characteristics and needs of different sectors of the national economy.

The principle of a systematic approach to the implementation of the policy of investing in clean technology means that only a wide range of interrelated measures and policy instruments that do not contradict each other, but on the contrary, reinforce each other, can bring a positive result.

An increasing number of countries are trying to solve the problem of efficient and economical use of energy resources by introducing the latest technologies. Innovations in the energy sector, as a rule, change at a slow pace because such technologies are quite large-scale, complex and difficult to implement and are created with a view to long-term operation. However, technological changes can have disturbances and gaps, especially under the pressure of such factors as: the geopolitical situation (for example, the oil crisis in 1973, known as the "oil embargo"), changes in energy policy (for example, the country's refusal to use nuclear energy), structural changes (like so-called *demographic tipping points),* when there is a declining trend in the population, which leads to a decrease in energy consumption). The rapid development of solar energy (photovoltaics), the production of electric vehicles and the growing demand for them, energy storage and storage technologies, etc. are today the main factors.

The end of the Cold War, accompanied by cheaper fossil fuels during the 1990s, reduced public awareness of energy saving and efficiency Due to domestic and global policy challenges, the need to respond to emerging risks, such as threats to public health and the environment due to global climate change, there is a need to develop "clean" energy technologies that would help reduce the use of expensive and at the same time "dirty" energy resources (based on fossil fuels).

Based on this, the policy of investing in "clean" technologies should be formed simultaneously within the following framework:

• setting strategic goals and policy coherence a clear and long-term vision and goals for the development of low-carbon infrastructure, coordination of various policies, multilevel governance (at the level of individuals, households, cities, regions and countries) with the possibility of involving stakeholders;

• formation of an attractive investment policy that would encourage investment in the sector of "clean" technologies creating open and competitive markets; introduction of regulatory policy that would stimulate investment in "clean" projects;

• financial policy and instruments. Support for long-term investments, introduction of innovative financial risk allocation mechanisms, such as "net" bonds or direct support for investments in "green" projects;

•use of resources and enhancement of the capacity of the green economy. Development of markets for new technologies, R&D funding, expansion of human and institutional capacity to support innovation, assessment of climate risks and their vulnerability of economic sectors;

• promoting the development of "green" business and further formation of environmentally responsible consumer behavior; the transition of enterprises to environmentally responsible production (mandatory reporting on the impact of the production on the environment), expanding information and encouraging consumers to consume environmental goods and use environmental services [7].

Thus, consistent and effective implementation of the principles of investing in "clean" technology, as well as "green" development in general, is possible only in a regulatory environment, transparent and fair, developing in accordance with the rule of law, with independent litigation, with independent market regulators acting in accordance with national interests, respecting the rights of investors and consumers.

Ukraine remains heavily reliant on gas and oil product imports. It is a key transit country for Russian gas exports to Europe. Recent economic crises, the closure of Russia's market, and escalation of the conflict in eastern Ukraine put downward pressure on growth, but the country’s GDP has seen an increase over the past few years. While energy policy has incentivized investment in renewables, possible policy reform reversals could impede further development. Since 2015, Ukraine has prioritized the reduction of natural gas subsidies in addition to diversifying energy supply. Ukraine is a part of the EU4Energy Programme, which focuses on evidence-based policy making for the energy sector [8].

The current system of financing environmental protection measures in Ukraine is characterized by the use of various investment resources - internal and external.
The internal ones include: availability of financial resources, ecological reputation of the enterprise and others. The external factors are: public policy, legally established laws, investor protection and others. One of the reliable and stable source is the own funds of enterprises. Unlike other resources, they are usually non-refundable. State budget funding for environmental projects is attractive, but virtually unavailable due to its limitations. For more effective functioning of financial relations in nature management, it is necessary to find additional sources of financing of ecological projects. Eco-investment management requires the introduction of an effective mechanism for attracting investments. An important element of the mechanism for implementing the state environmental policy, which aims to ensure environmentally oriented growth of the Ukrainian economy, is the financing system. The state of the environment in the country as a whole and its regions in particular largely depends on

how reliable and efficient this system is. Issues of financial support of the environmental sphere are becoming increasingly important in modern conditions. Research of advantages and disadvantages of sources of financing of nature protection measures, taking into account the western experience, proves that the most effective sources are means of international financial funds and programs and own sources.

State investment in environmental projects is carried out at the expense of state budget and other environmental funds in the form of tax benefits, grants and subventions. According to the State Treasury Service of Ukraine, the Ministry of Ecology and Natural Resources received funding from the state budget in 2020 for a total of 13239649.8 UAH, which was only 0.87% of total expenditures [5]. Financing of environmental investment programs by enterprises should be carried out in Ukraine due to the need to comply with environmental regulations. Such investments are mainly forced and are realized at the expense of the company's own funds, government allocations under grant support programs or soft loans. However, as a rule, nobody follows this rule.

As for the support of international financial funds and programs, it is necessary to admit that their share is one of the largest today. For this purpose, such tools are used as financial assistance programs, grants and preferential targeted loans. More than 100 international organizations are involved in environmental protection. The most famous is the Global Environment Facility, established in the early 1990s, which provides financial assistance to various projects in the field of environmental protection.

Among the important sources of environmental protection are bank loans. It should be acknowledged that currently Ukrainian commercial banks are reluctant to issue loans for environmental activities. International banks and organizations are actively working in lending to environmental ptojects: the International Bank for Reconstruction and Development, the European Bank for Reconstruction and Development, the World Bank, and the International Monetary Fund. All of them have identified environmental protection as one of the main tasks of their activities. Thus, the main tools for implementing the environmental policy of the European Bank for Reconstruction and Development are research in the field of environmental protection; technical assistance aimed at supporting environmental projects and programs; loans, guarantees, investments that provide financing for environmental projects, etc.

Recently, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) – a company working around the world, assisting the Government of Germany in achieving the goals of international cooperation for sustainable development and international education, launched in Ukraine the project "Best available technologies and management methods for Ukraine». It aims to promote the introduction of European best available techniques in Ukrainian industry to reduce industrial pollution and negative impact on the environment. GIZ supports the implementation of best available management technologies and methods (BAT) in Ukraine in four areas. The project will last until 2023, but it does not cover the entire scale of the process. The implementation of the BAT is likely to last until 2028 under the management of the Ministry of Energy and Environmental Protection of Ukraine.

If a Ukrainian producer wants to export its products to the European Union, but its production process is not ecologically safe enough, the EU can impose an import duty, the so-called carbon border, and the business will become uncompetitive. So, when there is a desire to be a successful exporter in the European Union, it will be necessary to carry out some modernization.

Businesses need to invest in clean technologies and processes, and this is always BAT. This is one of the aspects of motivation. The government can in some cases help businesses attract investment, as substantial sums of money are often needed to achieve the emission limit values set out in the BAT. This is the case when state intervention in the market is justified. It is planned to create a financing mechanism that reduces the burden on the business and at the same time requires it to invest part of its own funds in modernization (or take a loan from a bank).

The general trend of investing in environmental protection in the EU and Ukraine indicates a gradual decline. This situation may be due to the following factors: - aggravation of economic performance in the EU (UK exit from the European Union, influx of refugees from the Middle East, air pollution from cars, global warming, etc.); - complicated situation in Ukraine (corruption, war in the East, lack of an effective controlling body for environmental pollution, etc.) (Fig. 85).

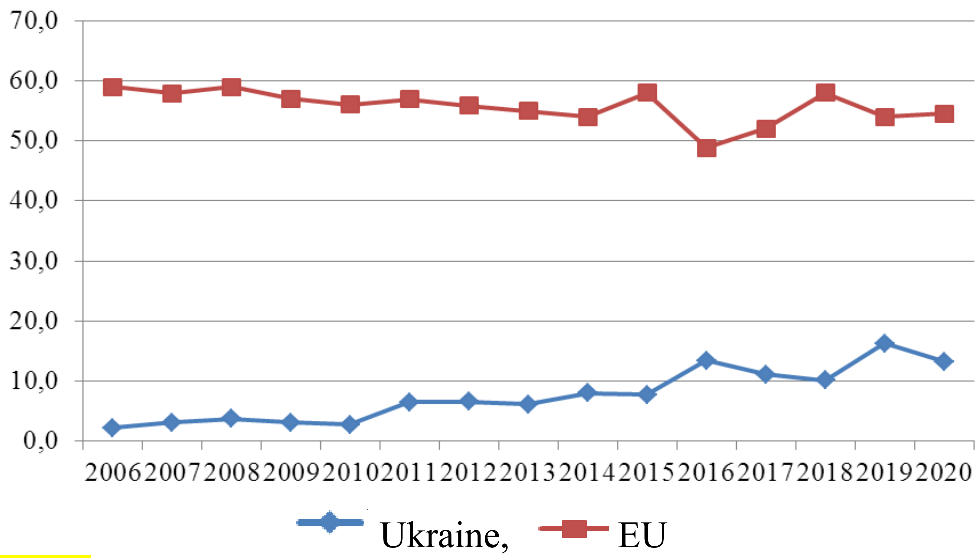


Figure 85. Investments for environmental protection, EU and Ukraine, 2006-2020, EUR billion.

Source: Developed by the authors based on Eurostat. Statistics Explained. Environmental protection expenditure accounts (2021) data.

International public financial flows to developing countries in support of clean and renewable energy reached $21.4 billion in 2017. This is 13 per cent more than in 2016 and double the level of 2010. Investment in hydropower projects represented 46 per cent of 2017 flows, followed by investments in solar (19 per cent), wind (7 per cent) and geothermal energy (6 per cent). While the progress is encouraging, only 12 per cent of these financial flows reached the least developed countries, which are the farthest behind in reaching Goal 7 targets. Focused attention is needed to ensure that financing reaches countries most in need (Fig. 86).

There are no single or simple solutions to putting the world on a sustainable path to net-zero emissions. Reducing global CO2 emissions will require a broad range of different technologies working across all sectors of the economy in various combinations and applications. These technologies are at widely varying stages of development, but can already map out how much they are likely to need to contribute to the emissions reductions necessary to meet international energy and climate goals.

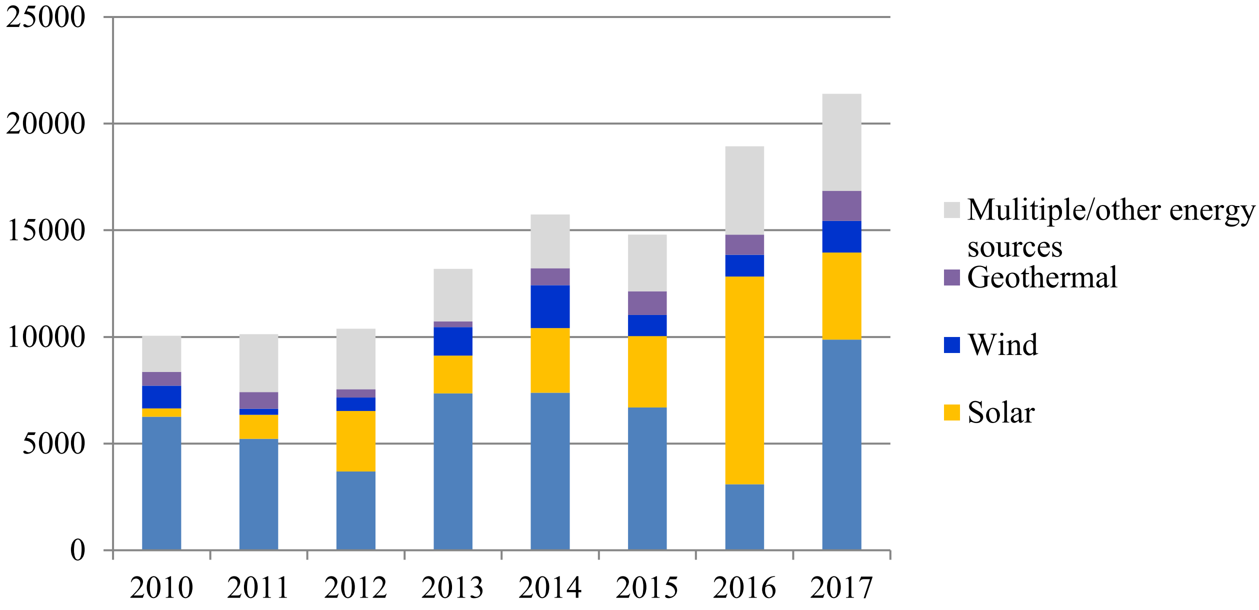


Figure 86. International financial flows to developing countries in support of clean and renewable energy by type of technology, 2010–2017 (billions of dollars at 2017 prices and exchange rates)

Source: Developed by the authors based on Ensure access to affordable, reliable, sustainable and modern energy for all (2020) data.

The key technologies the energy sector needs to reach net-zero emissions are known today, but not all of them are ready. Around half of the cumulative emissions reductions that would move the world onto a sustainable trajectory come from four main technology approaches. These are the electrification of end-use sectors such as heating and transport; the application of carbon capture, utilisation and storage; the use of low-carbon hydrogen and hydrogen-derived fuels; and the use of bioenergy. However, each of these areas faces challenges in making all parts of its value chain commercially viable in the sectors where reducing emissions is hardest [7].

The energy industry that emerges from the Covid-19 crisis will be significantly different from the one that came before. The worldwide economic shock caused by the Covid-19 pandemic is having widespread and often dramatic effects on investments in the energy sector. The companies are now reassessing strategies – and investors repricing risks – in response to today's profound uncertainties and financial strains. The energy industry that emerges from this crisis will be significantly different from the one that came before. The vulnerabilities and implications vary among companies, depending on whether they are investing in fossil fuels or low-carbon technologies, as well as across different countries.

The complexity of the global clean energy system makes it hard to assess how Covid-19 will affect the speed with which clean energy technologies can be developed and improved. This is compounded by widespread uncertainty about the longer term impacts of the pandemic. However, available data and historical precedent suggest significant cause for concern, given the urgency of the need to compress innovation timelines for clean energy technologies. There are signs that the global clean energy innovation system will be hard hit by spending cutbacks, especially in the private sector, with the largest impact in the near term being a tougher environment for scale-up and commercialisation. In simple terms, there is a risk that the "valley of death" becomes deeper and wider.

Before the pandemic hit, 2020 was expected to be a critical year for several major energy innovation policy initiatives, with keen interest in the details of the European Union's Horizon Europe and Innovation Fund, for example, and in the energy R&D elements of China's 14th Five‑Year Plan. These policies, and many others in preparation around the world, are still top priorities, but the immediate focus has shifted to managing revenue losses and economic recovery in most countries. At the same time, many companies are facing severe pressures, and all are having to adjust to a changed and uncertain economic outlook.

While the immediate task of protecting health and livelihoods is understandably occupying all parties in the first half of 2020, measures that directly or indirectly address clean energy innovation have nevertheless already featured in the policy responses of several governments. Details are still emerging, and other governments are still considering their positions; even so, these policy signals help to give at least an initial idea about how the environment for clean energy technology might evolve between mid-2020 and 2025 [9].

At a time when faster innovation is sorely needed, the Covid-19 pandemic has delivered a major setback. In the immediate future, the world's capacity to bring new technologies to market will be weaker as a result of the disruptions caused by the pandemic. Market and policy uncertainties threaten to reduce the funds available to entrepreneurs.

Innovation involves a wide range of participants, but governments have a pivotal role that goes far beyond simply funding research and development. They set overall national objectives and priorities, and are vital in determining market expectations, ensuring the flow of knowledge, investing in essential infrastructure, and enabling major demonstration projects to go ahead.

If governments rise to the challenge created by the Covid-19 crisis, they have an opportunity to accelerate clean energy innovation. This can help protect the approximately 750 000 jobs in energy research and development. And it can be a strategic opportunity for governments to ensure that their industries come out of the Covid-19 crisis stronger and ready to supply future domestic and international growth markets. On a path towards meeting sustainable energy and climate goals, we project that investments in technologies that are today at the stage of large prototype and demonstration would average around USD 350 billion a year over the next two decades.

Some areas deserve immediate attention from governments looking to revitalise economic activity. In particular, it is important to maintain research and development funding at planned levels through 2025 and to consider raising it in strategic areas. Market-based policies and funding can help scale up value chains for small, modular technologies – as they did for solar panels – significantly advancing technology progress. Synergies with other technologies across sectors is a relatively low-cost way to innovate. Electrochemistry, which underpins batteries, electrolysers and fuel cells is a clear example [7].

Technology innovation is widely recognised as critically important for tackling climate change and energy policy objectives, including increasing energy access and reducing air pollution. Yet tracking progress on innovation is challenging. The correlation between inputs – finances and skills – and intermediate outputs – patents and products – is sometimes unclear. Policy objectives such as cheaper technologies, industrial transformation and economic growth can be hard to measure or assign to the inputs. Despite this, a range of indicators can shed light on clean energy innovation globally, including funding and patenting. Broader sets of metrics are needed to identify and share good practices, and are being developed by some governments.

Low-carbon energy R&D spending in IEA member countries has been broadly stable since 2012, after doubling between 2000 and 2012. It remains below the levels in the 1980s, however. Low-carbon energy technology represents around 80% of total public energy R&D spending, which in 2019 grew by 3% to USD 30 billion globally. In general, the share of GDP represented by public energy R&D spending has remained fairly constant over the last decade, and other public research objectives, such as health and defence, receive around five times more R&D funding than energy.

Institutional investment in energy most commonly comes in the form of traded securities on equity and debt capital markets. Among the top 25 listed energy companies, by capital expenditure, investors accounted for nearly USD 1 trillion, or 25%, of the market value of these firms, as of early 2020. Excluding Saudi Arabia, whose initial public offering took place in late 2019, the capital markets represented nearly 40% of ownership. Institutional shareholding of listed equities varies by type of company, and investment opportunities tend to be more prominent with firms without recourse to government funding. For the private-sector energy companies, investors account for over half of shareholding, while for SOEs the share is less than 10%.

Over 80% of institutional capital for these companies comes from asset managers and brokerages, the largest holders of which include BlackRock, Vanguard, the Capital Group and State Street Global Advisors. While difficult to quantify, the investment strategies of the largest asset managers include a sizeable component of passive funds that follow established broad indices, compared with funds based on active strategies, where asset managers more frequently buy and sell shares. Pension funds and insurance companies, which typically employ active strategies, but with long time horizons, accounted for less than 10%, followed by sovereign wealth funds.

The first quarter of 2020 was marked by extraordinary movements in financial markets, with the market value of oil and gas companies, in particular, falling precipitously on the back of economic risks from the coronavirus, and prospects of a near-term oil supply glut. Even before these events, however, there was some evidence of investors pulling back from the largest energy companies. From the start of 2018 to the end of 2019, institutional investors pared shareholding in this group by around 6%. Share buybacks by some companies (e.g. oil and gas majors) during the past two years likely had influence on this, and there is considerable divergence in holdings among companies, partly reflecting investor uncertainty over how well some large players in the energy industry can position themselves in a changing market environment. The pullback included investors with sizeable passive holdings – as indices rebalanced, due to changing market prices and weightings, so did passive investor positions.

The energy investment implications of investor shareholding has both financial and corporate governance components. The buying and selling of shares is integral to corporate fundraising activities and the cost of capital, which can influence the selection of projects based on evolving risk and return requirements of investors, who have fiduciary duty to prudently manage the financial assets of their beneficiaries.

A larger question is the extent to which normally passive investors may become more active, seeking to wield more influence over energy companies in terms of strategy and decisions over capital expenditures and dividends. Stock ownership allows investors to vote on company issues and the selection of the board of directors at annual shareholders meetings. Already, some investors are taking stronger action to engage energy companies on sustainability issues and one indicator of change is the near-doubling of stewardship teams of major asset managers between 2017 and early 2020. Further monitoring is needed to assess investor commitments and industry impacts in this area, particularly amid the current economic downturn (fig.3).

Over the last decade, corporate energy R&D has seen years of growth, panctuated by slowdowns in response to economic challenges such as the 2007-08 financial crisis, the 2014 oil price crash and, now, the Covid-19 pandemic. In 2019, reported spending reached USD 90 billion, with a notable slowdown in the automobile sector, typically the highest spending sector for energy-related R&D but where revenues dipped and R&D spending was flat. While companies active in renewable energy showed an impressive 74% growth in R&D spending between 2010 and 2019, their share remains below one tenth of total corporate R&D.

Meanwhile sectors that do not yet have commercially viable solutions for deep decarbonisation, such as cement and iron and steel, typically spend relatively little on R&D.

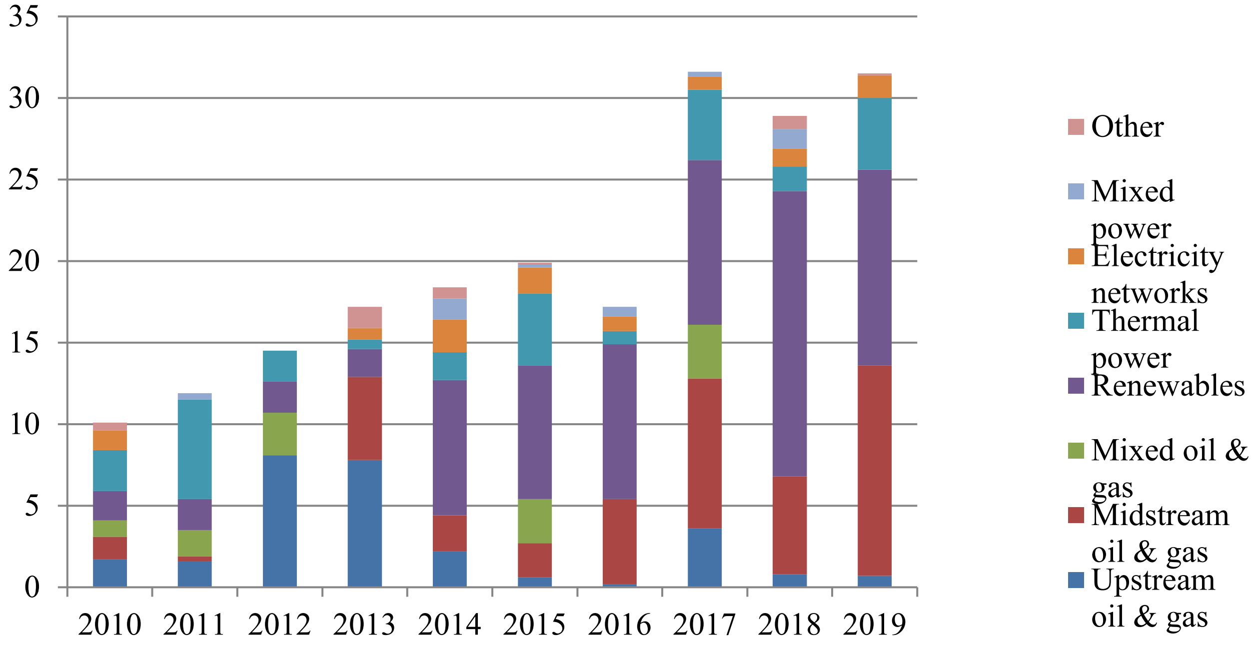


Figure 87. Institutional investor finance for energy project acquisitions and refinancing by sector, 2010-2019, USD billion

Source: Developed by the authors based on Energy financing and funding (2020) data.

Early-stage venture capital (VC) investment stood at USD 4 billion in 2019. Investment in growth areas, such as hydrogen and batteries, is broadening the impact of VC across sectors, and VC investment is growing in Europe, the People's Republic of China (hereafter "China") and the United States. However, the share of global VC deals accounted for by clean energy halved since 2012, indicating that the relative attractiveness of clean energy is not keeping pace with other technology areas, such as biotechnology and information technology. It is noteworthy in this context that, while the initial value of many energy technology start-ups lies in the patents they hold, fewer patents have been filed for low-carbon energy technologies each year since 2011.

The Covid-19 pandemic has had a rapid and negative impact on private sector funding for clean energy innovation, and is likely to set back the speed with which clean energy technologies can be developed and improved. In the absence of policy interventions, demonstration, early adoption and learning-by-doing are expected to suffer the most in the first instance. A number of energy-related companies reported year-on-year declines in R&D budgets in the first quarter of 2020, and the number of VC deals was also down. The impacts are likely to be uneven across countries, with emerging economies finding it hardest to plug gaps in innovation systems.

In sum, given the complexity of solutions to reach sustainable development goals and a need to scale up investment for a range of technologies, by a large range of actors, transition bonds are likely to remain a part of financing and policy discussions, though likely with increased focus on guidelines to improve standards and transparency.

REFERENCES

1.Khomutenko L. I., Kirilieva A. V. (2020) Pryntsypy formuvannya «zelenoho» investuvannya krayiny, rolʹ ta znachennya dlya konkurentospromozhnosti [Principles of formation of the green investment of the country: the role and importance for competitiveness]. *Economy,* № 1 2020*,* 55-61. DOI: 10.21272/ 1817-9215.2020.1-06

2.Tsyhan R., Pokhyton I. (2020). Obgruntuvannya neobkhidnosti stvorennya umov zaluchennya ekolohichnykh investytsiy u diyalʹnistʹ pidpryyemstv Ukrayiny [Rationale of the necessity to create conditions of involvement of environmental investments in the activities of Ukraine's enterprises] *Efektyvna ekonomika* (Ukraine). Retrieved from: http://www.economy.nayka.com.ua/pdf/1_2020/83.pdf (Last accessed: 28.07.2021). DOI: 10.32702/2307-2105-2020.1.81

3.The official website of the European Union (2020), Eurostat, Statistics Explained, "Environmental protection expenditure accounts". Retrieved from: http://1.https//ec.europa.eu. (Last accessed: 28.07.2021).

4.The official website of Ukraine ukrstat (2020), "State Statistics Service, Economic Statistics, Environment". Retrieved from: http://www.ukrstat.gov.ua/ (Last accessed: 28.07.2021).

5.The official website of the European Union (2020), "European Statistics Service, Environmental tax revenues". Retrieved from: https://appsso.eurostat.ec.europa.eu (Last accessed: 28.07.2021).

6.The official website of the United Nations Statistics Division (2020), "Ensure access to affordable, reliable, sustainable and modern energy for all". Retrieved from: https://unstats.un.org/sdgs/report/2020/goal-07/(Last accessed: 28.07.2021).

7.The official website of the International Energy Agency (2020), "Energy financing and funding". Retrieved from: https://www.iea.org/reports/world-energy-investment-2020/energy-financing-and-funding (Last accessed: 28.07.2021).

8. The official website of the International Energy Agency (2020), "Ukraine". Retrieved from: https://www.iea.org/countries/ukraine (Last accessed: 28.07.2021).

9. The official website of the International Energy Agency (2020), "Global status of clean energy innovation in 2020". Retrieved from: https://www.iea.org/reports/clean-energy-innovation/global-status-of-clean-energy-innovation-in-2020 (Last accessed: 28.07.2021).