Aligning the environmental and social values of the sustainable development concepts, Industry 5.0 and Society 5.0

Zhanna Mingaleva [1 *], *Olga* Startseva [2], *Anatoly* Gerasimov [1]

[1] Perm National Research Polytechnic University, 614990 Perm, Russia
[2] Regional public organization of the Sverdlovsk region "Ural Environmental Expertise", 620075 Ekaterinburg, Russia

Abstract. *The relevance of the issue* is due to the intensification of global crisis phenomena in the field of ecology and social sphere, the increasing imbalance of the world economy, the insufficient scale of implementation in practical activities of environmental and social aspects of development that contribute to the sustainable growth of society. *Goal of the issue* is to identify how the environmental and social values of modern global sustainable development are taken into account in regulatory international and national documents, in the concepts of Industry 4.0, Industry 5.0 and Society 5.0 and how they are consistent with each other. *Research methods* include bibliographic analysis, comparative analysis, cliometric methods, modeling. The reports and scenarios of the Club of Rome for 1972-2023, studies of large consulting companies were used as a database. *Results.* The study revealed a gradual strengthening of the role and importance of environmental and social values in international documents and policies in the field of sustainable development. However, these rates are not sufficient to form favorable trends in the field of sustainable development and overcome the movement of humanity along the trajectory of the crisis. *Conclusions.* Based on the results of the study, it was concluded that following only economic goals without an active transition to achieving environmental and social goals based on corresponding values leads humanity to climate and social crises.

1 Introduction

"Industry 5.0" is not an independent stage of the modern industrial revolution, described as "Industry 4.0", but rather acts as an ideal vision of future industrial development, developed in the European Union and supported by a number of countries, including the USA, Russia, and China. The Industry 5.0 framework complements the existing Industry 4.0 approach by "putting research and innovation at the service of the transition to a sustainable, people-centered and resilient European industry" [1]. The concept of "Industry 5.0" contributes to the implementation of three priorities of the European Commission, namely: "An economy that works for people" - ensuring social justice and prosperity [2], "European Green Deal" -

*Corresponding author: mingal1@pstu.ru

Europe strives to become the first climate-neutral continent, becoming modern, resource-efficient economy [3] and “Europe ready for the digital age” - empowering people with the help of new generation technologies [4].

These three EU priorities correlate with the UN sustainable development goals (SDG), which are also aimed at implementing the key values and global decisions that are most important for the development of all mankind [5]. Regarding the prospects for global industry, the European Commission has developed the following long-term directions for action regarding the future of industrial production:

- adoption of a human-centric approach to digital technologies, including artificial intelligence (AI Regulation Proposal) [6];
- upskilling and retraining of European workers, especially digital skills (Skills Program [7] and Digital Education Action Plan [8]);
- modern, resource-saving and sustainable production and the transition to a circular economy (“Green Deal”) [3];
- a globally competitive and world-leading industry accelerating investment in research and innovation (Industrial Strategy) [9].

The concept of "Industry 5.0" is often compared with the concept of "Society 5.0" (or Super Smart Society) adopted in Japan back in 1971 as part of the national socio-economic and cultural strategy for the development of a society that widely uses digital technologies in all spheres of life. At this Japanese government announced myself initiator creation And leader implementation such a super-smart society - Society 5.0: “Japan will take the lead to realize this ahead of the rest of the world” [10]. Formulating basic goals And values such a super-smart society, Japanese government stated : “We aim at creating a society where we can resolve various social challenges by incorporating the innovations of the fourth industrial revolution (eg IoT, big data, artificial intelligence (AI), robot, and the sharing economy) into every industry and social life. By doing so the society of the future will be one in which new values and services are created continuously, making people's lives more conformable and sustainable" [11]. Development of the concept "Society 5.0" (Super Smart Society) was at one time the country's reaction to the first studies of the Club of Rome, conducted in the 60s of the twentieth century.

The response of other countries, including the USA and EU countries, as well as the regulatory bodies of the Union as a whole, as well as the Club of Rome, to the dissemination of the ideas of Society 5.0 in the world was the adoption of various national strategies that use environmental criteria in predicting the future technological development of countries and regions targeting to promote a new approach to human capital development and assessment of human-machine interactions, based on a broader list of environmental and social values.

Thus, the most frequently mentioned in connection with the application of the principles of Industry 5.0 and the widely known national strategy in the field of application of Industry 4.0 technologies is Hightech Strategy 2025 (HTS), adopted in 2006 in Germany [12]. “The HTS 2025 defined 12 long-term missions to be accomplished as a concerted effort across almost all federal ministries to tackle major six global challenges: 'Healthcare', 'Sustainability, Climate Action and Energy', 'Mobility', 'Urban and Rural' Areas', 'Safety and Security', and 'Economy and Work 4.0'" [12].

This strategy, on the one hand, provides the basis for the RTDI-oriented policy of the German Federal Government, but on the other hand, its goals and objectives are constantly adapted to newly emerging challenges, including strategic needs, with each new legislative period.

The concepts of Society 5.0 and Industry 5.0 as a continuation of the concept of Industry 4.0 are becoming increasingly widespread in Russian society and the scientific community.

In this regard, it is of important scientific, practical and political interest to study how and in what direction the place and role of environmental and social values are changing as the practice of applying the Industry 5.0 concept expands. We will carry out the processes and directions of transformation of global values, which occurs as humanity realizes the threats to its development due to technological and industrial growth, on the basis of key reports of the Club of Rome.

2 Materials and methods

The main research methods are bibliographic analysis, comparative analysis, and cliometric methods. Data from international and national organizations in the field of strategic development were used as a database, including the UN Global Compact for Sustainable Development, Climate Agenda (Paris Agreement), Japan Development Strategy "Society 5.0", Hightech Strategy 2025 (HTS) of Germany, research by KPMG experts and other materials. The recommendations and conclusions contained in the reports of the Club of Rome for 1972-2023 and the scenarios of world development until 2100 proposed in them were also carefully analyzed.

Among the reports for the Club of Rome, the main emphasis was placed on studying the first report "The Limits to Growth" (1972) [13], two subsequent works by Donella and Dennis Meadows ("Beyond the Limits", 1992 [14] and "The Limits to Growth: The 30-Year Update", 2004 [15]), the report "Taking Nature Into Account: A Report to the Club of Rome Toward a Sustainable National" (1995) [16], the Club of Rome report " Bankrupting Nature: Denying Our Planetary Boundaries " (2012) [17], "Extracted: How Mining Is Ruining the Planet " the Quest for Mineral Wealth is Plundering the Planet" (2014) [18], "Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation" (2019) [19], "Limits and Beyond: 50 years on from The Limits to Growth , what did we learn and what 's next? (2022) [20] and the report "Earth for All – A Survival Guide for Humanity" (2022) [21].

3 Research part

Half a century ago, in 1972, "The Limits to Growth" book, presented to the Club of Rome by a team from the Massachusetts Institute of Technology, described the study devoted to how people use the Earth's resources. Using sophisticated computer modeling, an international team of researchers looked at five major factors that determine and ultimately limit growth on this planet - population growth, agricultural production, depletion of non-renewable resources, industrial production and pollution; entered data on these five factors into a global computer model and then tested the model's behavior under several sets of assumptions to identify alternative models for the future of humanity. MIT researchers have developed scenarios where they map out possible paths for humanity, the global economy, and the impact on the planet. A total of 12 such scenarios were developed. One of them is a basic scenario, the second is the most desirable, the third is the most realistic. The next two scenarios are considered conditionally positive. The remaining 7 scenarios are negative. The differences in the scenarios are shown in Figures 1-4. They are as follows:

- a basic scenario - the World3 BAU model ("If nothing is done", "business as usual") (Figure 1) [15, p.169],
- a scenario BAU2 (World 3(2004)), which is a modification of the basic scenario BAU (Figure 2) [15, p.173],
- complex technology (CT) scenario (Figure 3) [15, p.219],
- Stabilized World (SW) scenario (Figure 4) [15, p.245].

All figures are based on the 2004 Club of Rome report, "The Limits to Growth: 30 Years Later", also prepared by a team led by D. Meadows, taking into account the changes that have occurred over the 30 years since they built the first digital model of global equilibrium - World 3 (1972) [15].

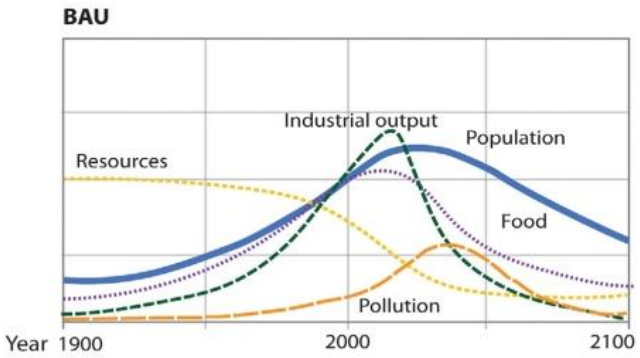

Fig. 1. The World3 BAU model (1972).

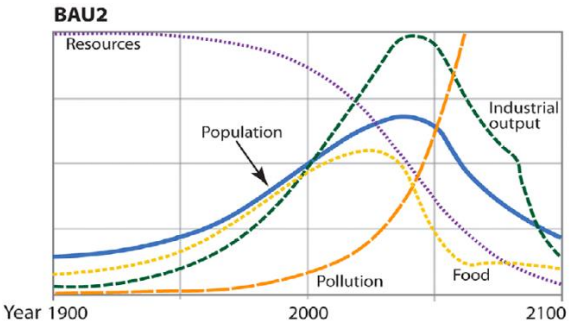

Fig. 2. The World3 BAU2 model (2004).

BAU 2 scenarios, as well as the CT scenario, show growth stopping around 2040-2050. Thus, both scenarios indicate that it is impossible to continue to conduct business on the same terms, as well as strive for constant growth. Even in combination with active technological development based on new digital technologies, additive technologies and artificial intelligence, ordinary businesses will face the simulated "Limit to Growth" (LtG) if they do not widely apply resource-saving and environmentally friendly technologies.

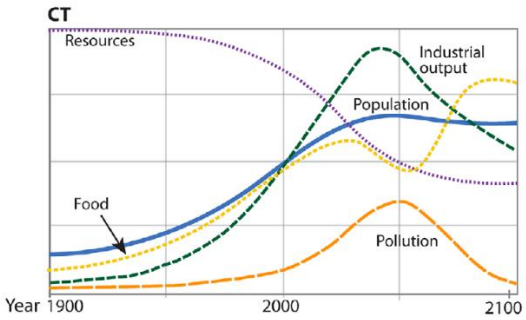

Fig. 3. Complex technology (CT) scenario.

Thus, both scenarios (BAU2 and CT) confirm the development of negative trends in all areas of social activity.

The Stabilized World (SW) scenario is the most optimistic and desirable, since according to it, humanity experiences the least decline in economic growth, slowdown in industrial production, food shortages and does not limit natural population growth (see Figure 4).

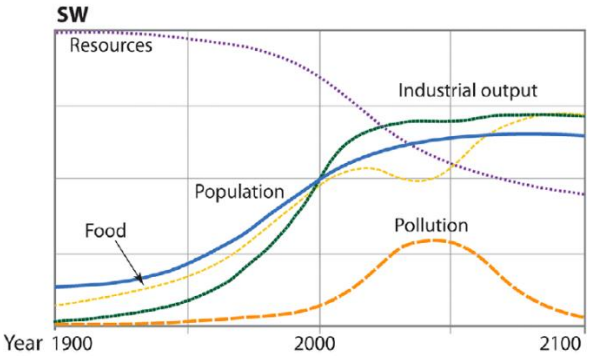

Fig. 4. Stabilized World (SW) scenario

However, all researchers note that this scenario is least true.

Different growth patterns proposed in the book by D. Mndouz et al. in 1972 have been subjected to numerous empirical tests, both by the authors of the theory of Limits to Growth (LtG) and by other researchers. Moreover, the reaction to the trends confirming the correctness of the World3 BAU model was different. Some authors completely agreed with the conclusions and forecasts of D. Mendoza's groups, while others, on the contrary, believed that the World3 BAU model and the BAU2 scenarios unnecessarily dramatize the situation [22-24].

One of the most reasoned and substantiated confirmations of the correctness of the forecasts of D. Mendouz's group is the research of Graham Turner [25-27].

Australian physicist Graham Turner compared actual data from 1970 to 2000 with a baseline scenario (BAU2). Turner found that predictions closely matched actual data across all key development areas (see Figure 5) [28]. Statistical and mathematical testing of other scenarios showed significantly greater discrepancies with the trend lines. Thus, Graham Turner proved that despite numerous warnings about the danger of exhausting natural (ecological) and resource growth opportunities, negative trends persist in full, and humanity is moving along an undesirable development trajectory. Therefore, it is necessary to strengthen the influence of social and environmental components in the development strategies and programs of national states. Greater efforts need to be made to mainstream environmental and social values into people's behavior.

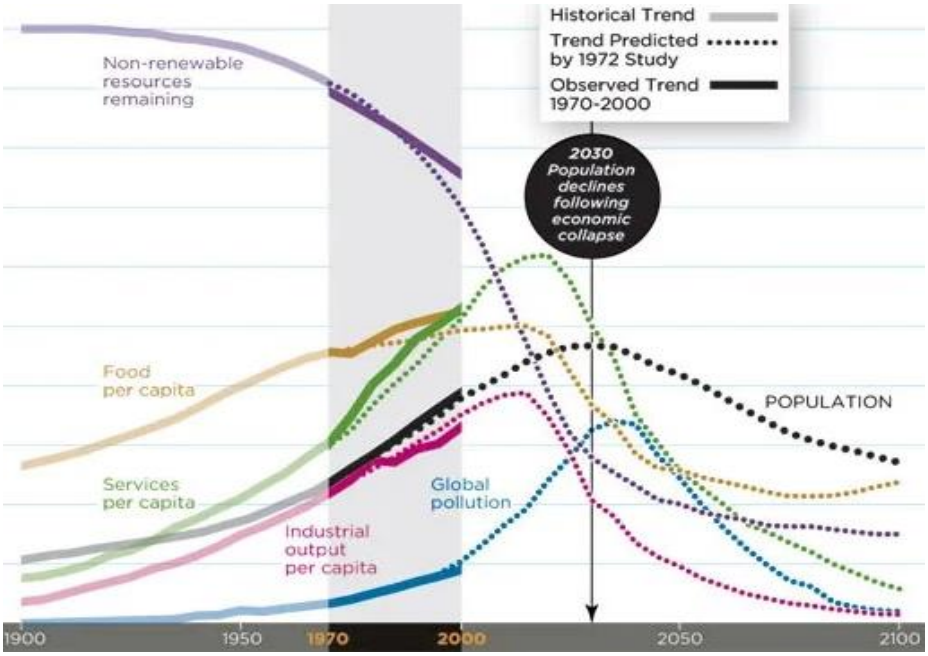

Fig. 5. The World3 BAU model with Graham Turner calculations

Results of Gaia Herrington's research, who is a head of stability and dynamic systems analysis department at KPMG and an adviser of the Club of Rome, also confirms the 50-year-old prediction [29]. The title of her book "Renewing the Limits to Growth: Comparing the World 3 BAU Model with Empirical Evidence" makes clear the need to change approaches to global development. Her research also showed that the basic 1972 World3 scenario remains valid today - that if current trends continue, the Earth's interconnected resources will not be able to sustain current rates of economic and population growth well beyond 2100, even with advanced technology.

Subsequent long-term and numerous calculations to test various global development scenarios have shown that humanity is still moving precisely according to the basic scenario, which is largely negative [30-31].

Research has confirmed that the current situation is even closer to critical, and the conclusions drawn are disappointing: climate risks are accelerating, the environmental situation is deteriorating, and the water and food crises are accelerating.

4 Results

Based on a thorough study of the main international documents in the field of sustainable development, the main features of international approaches to sustainable development, reflected in reports and global development scenarios, were identified.

The meaning of traditional "industrialization" is the conquest of nature and the extraction of all natural resources for the needs of industry, without taking into account the needs of society and nature. The First (1784, Industry 1.0) and Second (1870, Industry 2.0) industrial revolutions are characterized by exclusively economic motives and values, which are based on the increasing involvement of a variety of resources in production, including the intensification of the use of labor and the extensive use of natural resources. At the stage of Industry 2.0, there is not only electrification and the introduction of conveyor production, but also the massive use of chemicals - varnishes, paints, etc., which cause enormous harm to

both the environment and human health. Environmental and social aspects were not taken into account at all at this time. The result of the Second Industrial Revolution (Industry 2.0) was a sharp increase in environmental pollution in the world, as well as the physical depletion of many minerals, which by the middle of the twentieth century became a real obstacle to increasing production volumes at the same pace.

The period of the Third Industrial Revolution (since the 70s of the twentieth century, Industry 3.0) is characterized by the greatest negative impact on the environment, during which the balance of ecosystem restoration was disrupted. Humanity began to live on borrowed money from future generations, cutting down a critical mass of forests, polluting the world's oceans and other bodies of water, soil, and air. A critical situation has developed with atmospheric pollution with greenhouse gases and other harmful emissions, making the atmosphere in many megacities very dangerous for human health and the natural environment.

Unfortunately, industry 4.0 (21st century) does not pay enough attention to environmental protection too, as well as to technologies aimed at improving environmental sustainability, although many different artificial intelligence algorithms have been used for sustainability research over the past decade. The main emphasis is placed on the advantages of digital technologies, which should make production and life easier and more efficient, and on justifying the need for their mass use [32-33]. Digital technologies are widely and effectively used in managing organizational knowledge of companies from the point of view of maintaining their competitiveness [34-35]. For example, the importance and significance of a company's organizational culture as an element of the social sphere for maintaining the sustainability of its workforce is not yet sufficiently taken into account in the ESG strategies of companies, although many scientists point to this [36-37]. At the same time, many social and environmental values remain in the Industry 4.0 concept without attention. The way to eliminate this discrepancy is to pay more attention to the environmental and social components of modern development, implemented in the concepts of Industry 5.0. and Society 5.0.

The term "Industry 5.0" was used in Germany at CeBIT 2017 in Hannover, largely as an analogy to the term Society 5.0, which underlies Japan's development strategy [38].

However, Industry 5.0 should not be understood as a chronological continuation or alternative to the existing Industry 4.0 paradigm. As a part of the fundamental approach to understanding society and the paths of human development formulated in the concept of Society 5.0, the concept of Industry 5.0 is the result of a forward-looking vision, a good way to determine how industry, new trends and the needs of society will coexist and be coordinated in the near future. In essence, Industry 5.0 complements and expands the capabilities of Industry 4.0, bringing them into line with new requirements, primarily social and environmental.

The concept of Industry 5.0 combines several interrelated concepts that are fundamental in developing a long-term strategy for any country and the world as a whole and involves the adoption from all of humanity of a certain type of behavior aimed at progress and human well-being based on the reduction and shift of consumption to new forms of sustainable, circular and regenerative economic value creation and equitable prosperity.

Industry 5.0 goes beyond simply producing goods for profit. Its fundamental principles are: sustainability, people-centredness and resilience [39]. Characterized by: a sustainable system powered by renewable energy sources, the use of biotechnology; robots do repetitive and dangerous work while humans focus on creativity; digital big data analytics and blockchain; the highest level of production sustainability; digital monitoring of climate, ecology, energy consumption and other material resources in real time. Industry 5.0 will pave the way for the harmonious interaction of human intelligence with cognitive computing.

The Industry 5.0 concept is essentially a framework for combining the capabilities of Industry 4.0 technologies with a human-centric approach [40]. Industry 5.0 is trying to balance economic development with solving social and environmental problems through digital technologies [41-42].

Commission EU characterizes Industry 5.0 in their regulatory documents in the following way: “This approach provides a vision of industry that aims efficiency beyond and productivity as the sole goals, and reinforces the role and the contribution of industry to society.” It places the wellbeing of the worker at the center of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet. It complements the existing "Industry 4.0" approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric and resilient European industry" [39].

As we have already noted, the concept of Society 5.0 represents the Japanese vision of a superintelligent society “aimed at solving social problems from a new perspective. In this new era, various aspects will be connected and technology will join the super-intelligent society with full integration of big data, Internet of Things, artificial intelligence and people services to facilitate digital and physical infrastructure for people.”

In the modern interpretation, the concept of Society 5.0 takes into account all 17 SD goals [43-44]. A sustainable society is engaged in and cares for its present without compromising the possibilities of the future, thus organizing itself to improve the quality of life and autonomy of its constituent citizens and the pursuit of common well-being. Social processes and resources must be distributed in such a way as to enable smarter decisions, the development of technologies and practices, and the creation of a society that values diversity.

Thus, in Society 5.0, clean energy will be provided to everyone when local and decentralized power grids are developed. New digital technologies will be used to prevent natural disasters and mitigate their consequences. Medical care will continue even during emergencies. Big data, data science and artificial intelligence are critical research and development technologies that must be accurately integrated to achieve the goals of Society 5.0. These goals aim to improve the merging of cyberspace and physical space. Therefore, information will be collected from several types of sensors located in physical spaces and compiled using the Internet of Things.

Sustainable innovation in Society 5.0 is considered a fundamental concept and is understood as a process in which sustainable environmental, social and financial considerations are integrated into organizational systems. Sustainable development is a key concept in the innovation processes of Society 5.0 due to its deep significance in the economic, social and environmental dimensions, it strives to create a more competitive economy that generates sustainable economic growth with more and better jobs and social cohesion, leading to sustainable and inclusive growth.

Returning to the question of the need to take environmental and social values into account deeper in programs and strategies for sustainable development, let us turn to the list of environmental and social problems that currently exist and are recorded in the concepts of Industry 5.0 and Society 5.0, but are still extremely poorly regulated. These are the following major environmental and social issues:

- predicted shortage of natural resources that cannot be recreated or replaced, as well as depletion of known elementary elements;
- climate change;
- shortage of drinking water. At the end of 2022, the 1st report of the World Meteorological Organization “The State of Global Water Resources 2022” was released, based on the results of an analysis of the impact of climate, environmental and social changes on the Earth’s water resources [45]. Currently, 3.6 billion people face the problem of insufficient access to water for at least one month a year. By 2050, >5 billion people on Earth

will experience water shortages to varying degrees. Between 2001 and 2018, water was involved in 74% of all natural disasters on Earth. The report notes that negative trends will be stronger than positive ones, that is, surface water reserves will gradually decrease;

- food crisis, which continues to grow in the world;
- deepening demographic crisis;
- growing problems of migration and integration ;
- problem of rising unemployment and general employment issues; problems of social security, including issues of raising the retirement age and other aspects of pension reforms in a number of countries around the world;
- problems of health care systems development in general and accessibility of medical care;
- problems of social justice and equality, etc.

5 Conclusions

The growth of global crisis phenomena in the world, confirming the implementation of the pessimistic scenario for human development by 2100, presented back in 1972 to the Club of Rome, requires a search for answers to the question of the reasons for the persistence of negative development trends in general, as well as in the field of ecology and social sphere, the reasons for the increase imbalances in the global economy and finding ways to eliminate them.

Based on the analysis, it was established that since the Second Industrial Revolution (Industry 2.0), the world has seen a significant increase in environmental pollution. Unfortunately, Industry 4.0 has not paid enough attention to environmental protection or technologies aimed at improving environmental sustainability, although many different artificial intelligence algorithms have been used for sustainability research over the past decade. The meaning of traditional “industrialization” is the conquest of nature and the extraction of all natural resources for the needs of industry, without taking into account the needs of society and nature.

At the same time, the solution to most social issues also remained outside the scope of global development programs. Therefore, at present, humanity is acutely faced with such unresolved basic social problems and threats of our time as: the problem of social justice and equality, the problem of rising unemployment and employment problems, the negative impact of social networks, the problem of accessibility of medical care, problems of migration and integration, demographic crisis, threats to cybersecurity and information security.

The study showed that the transition to balanced development is possible based on the transformation of economic, environmental and social values in industry and society, through the transition to Industry 5.0 and Society 5.0, the inclusion of concepts 5.0 and Society 5.0 in national and international strategies and long-term development programs. In particular, the study found that solving a number of problems is impossible without their unconditional recognition and full consideration in all national and international documents, including social and environmental values in regulatory documents at all levels and on a full scale - in the form official terminology, development goals, evaluation indicators, etc.

Based on the results of the study, it was concluded that following only economic goals without an active transition to achieving environmental and social goals based on corresponding values leads humanity to climate and social crises. Therefore, modern international and national strategies and long-term development programs should be more focused on achieving environmental and social values, which will allow achieving balanced development according to all key criteria of the economy, ecology and society.

References

1. Industry 5.0. What this approach is focused on, how it will be achieved and how it is already being implemented. Available online: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/industry-50_en. Accessed 01 October 2023 (2023)
2. The European Commission's priorities. An economy that works for people. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/economy-works-people_en. Accessed 01 October 2023 (2019)
3. The European Commission's priorities. The European Green Deal. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en Accessed 01 October 2023 (2019)
4. The European Commission's priorities. A Europe fit for the digital age. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en Accessed 01 October 2023 (2019)
5. D. Griggs, M., Stafford-Smith, O. Gaffney, J. Rockström, M.C. Öhman, P. Shyamsundar, W. Steffen, (...) and I. Noble, Nature, **495** (7441), 305-307 https://doi.org/10.1038/495305a (2013)
6. Proposal for a R EGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1623335154975&uri=CELEX%3A52021PC0206. Accessed 01 October 2023 (2023)
7. European Skills Agenda - Employment, Social Affairs & Inclusion. Available online: https://ec.europa.eu/social/main.jsp?catId=1223. Accessed 01 October 2023 (2023)
8. Digital Education Action Plan (2021-2027). Available online: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12453-Digital-education-action-plan-update-_en. Accessed 01 October 2023 (2021)
9. European industrial strategy. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en. Accessed 01 October 2023 (2019)
10. ABENOMICS. For future growth, for future generations, and for a future Japan that is robust. Published in May 2017. Available online: https://www.japan.go.jp/abenomics/_userdata/abenomics/pdf/society_5.0.pdf. Accessed 01 October 2023 (2017)
11. Society 5.0. Available online: https://www8.cao.go.jp/cstp/english/society5_0/index.html. Accessed 01 October 2023 (2017)
12. Hightech Strategy 2025. https://stip.oecd.org/moip/case-studies/1?answerId=A1-1. Accessed 01 October 2023 (2021)
13. D. H. Meadows, D. L. Meadows, J. Randers, W. W. Behrens III, The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind (New York, Universe Books, 1972)
14. D. H. Meadows, J. Randers, D. L. Meadows, Beyond the Limits (Chelsea Green Publishing, 1992)

15. D. H. Meadows, J. Randers, D. L. Meadows, The Limits to Growth: The 30-Year Update (White River Junction VT: Chelsea Green Publishing Co., 2004)
16. W. van Dieren, Taking Nature Into Account: A Report to the Club of Rome Toward a Sustainable National (Springer New York, 1995)
17. A. Wijkman, J. Rockström, Bankrupting Nature: Denying Our Planetary Boundaries (Routledge, 2012)
18. U. Bardi, Extracted: How the Quest for Mineral Wealth Is Plundering the Planet 2014. (Chelsea Green Publishing, 2014)
19. P. Kuenkel, Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation (Springer, 2019)
20. U. Bardi, A.P. Carlos, eds. Limits and Beyond: 50 years on from The Limits to Growth, what did we learn and what's next? A Report to The Club of Rome (Exapt Press, 2022)
21. S. Dixson-Decléve, O.Gaffney, J.Rockström, J. Ghosh, J. Randers, P. E. Stoknes, Earth for All: A Survival Guide for Humanity (New Society Publishers, 2022)
22. M. R. Simmons, Revisiting The Limits to Growth: Could the Club of Rome Have Been Correct After All? (Mud City Press, 2000)
23. U. Bardi, Cassandra's Curse: How The Limits to Growth was demonized (The Oil Drum: Europe, 2008)
24. P. A. Victor, Managing without growth: slower by design, not disaster (Cheltenham, UK: Edward Elgar, 2008)
25. G.Turner, Glob Environ Change **18 (7),** 397-411 (2008) https://doi.org/10.1016/j.gloenvcha.2008.05.001
26. G.Turner, A. Cathy, *Limits to Growth was right. New research shows we're nearing collapse (*The Guardian, 2014)
27. G.Turner, Is Global Collapse Imminent? An Updated Comparison of TheLimits to Growth with Historical Data. (Research Paper No. 4) About MSSI Research Papers (2014)
28. M. Strauss. Looking Back on the Limits of Growth, Smithsonian Magazine, (2012)Available online: https://resiliencesystem.org/looking-back-limits-growth
29. G. Herrington, J. Ind. Ecol. **25 (3)** 614–626 (2020) https://doi.org/10.1111/jiec.13084
30. J. Randers, 2052: A Global Forecast for the Next Forty Years. White River Junction VT (Chelsea Green Publishing Co., 2012)
31. C. Parenti, The Limits to Growth': A Book That Launched a Movement (The Nation, 2012)
32. N. Lukovnikov, Z. Mingaleva, O. Zakirova, Y. Starkov, Lect. Notes Netw. Syst. **381** 38-47 (2022) https://doi.org/10.1007/978-3-030-93677-8_4
33. J. S. Avery, Information Theory and Evolution. Singapore: World Scientific **233** (2012)
34. Z. Mingaleva, L. Deputatova, Y. Starkov, Lect. Notes Netw. Syst. **78,** 203-212 (2020) https://doi.org/10.1007/978-3-030-22493-6
35. T. Hák, S. Janoušková, A. Whitby, Sustainability (Switzerland) **7**, 3414-3429 (2015) https://doi.org/10.3390/su7033414
36. Z. Mingaleva, O. Borisova, D. Markov, Y. Grigorieva, Lect. Notes Netw. Syst. **381**, 48–56 (2022) https://doi.org/10.1007/978-3-030-93677-8_5

37. Z. Mingaleva, E. Shironina, E. Lobova, L. Plyusnina, A. Oborina, Sustainability (Switzerland) **14(10),** 6289 (2022) https://doi.org/10.3390/su14106289
38. Industry 4.0 vs. Industry 5.0: Understanding the Real Difference. Available online: https://amfg.ai/2023/03/17/industry-4-0-vs-industry-5-0-understanding-the-real-difference/. Accessed 11 October 2023 (2023)
39. Industry 5.0: A Transformative Vision for Europe ESIR Policy Brief No. 3. European Commission Directorate-General for Research and Innovation. European Commission. ISBN 978-92-76-43352-1 doi: 10.2777/17322 , 30 p. (2021)
40. Ch. Berg. What is Industry 5.0? March 31, 2022. Available online: ttps://www.clarify.io/learn/industry-5-0. Accessed 25 October 2023 (2023)
41. Y. Zhang, Z. Wu, Sci. Total Environ **838,** 156491 (2022) https://doi.org/10.1016/j.scitotenv.2022.156491
42. P. Bartelmus Green accounting: Balancing environment and economy, Routledge Handbook of Sustainability Indicators, 235-257 (2018)
43. E. Dinerstein, C. Vynne, E. Sala, A.R. Joshi, S. Fernando, T.E. Lovejoy, J. Mayorga, (...), E. Wikramanayake, Sci. Adv. **5 (4)**, 2869 (2019) https://doi.org/10.1126/sciadv.aaw2869
44. New foresight report identifies urgent policy actions needed to put SDGs back on track. Available online: https://www.eurekalert.org/news-releases/1000850. Accessed 01 October 2023 (2023)
45. State of Global Water Resources 2022. The WMO State of Global Water Resources Report 2022. Available online: https://public.wmo.int/en/our-mandate/water/state-of-global-water-resources-2022. Accessed 01 October 2023 (2022)