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## CHAPTER 3

# Synergy of digital technologies and green development and their impact on achieving a sustainable environment in the conditions of instability

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Valentyna Voronkova  
Vitalina Nikitenko  
Natalya Metelenko  
Iryna Silina  
Alla Popova  
Slyusar Mykyta  
Burashnikova Olena  
Roman Afonov

### Abstract

The aim of this research is to assess the influence of digital technologies on fostering sustainable green development, thereby enhancing resource efficiency, reducing emissions, improving energy efficiency, and advancing environmental management. Investigating the impact of digital technologies on sustainable green development is pertinent due to their potential to enhance the effectiveness of renewable energy sources, like solar panels and wind turbines, through weather forecasting, system optimization, and energy storage. Moreover, digital technologies can facilitate resource efficiency and the adoption of circular economy models, converting waste into valuable resources. The paper aims to scrutinize leading international practices in leveraging digital technologies for sustainable development and to delineate their role in achieving sustainable green development. Sensor networks and Internet of Things (IoT) systems enable precise data collection on resource utilization, air and water pollution, enabling targeted interventions. The paper delineates how digital technologies optimize energy consumption in buildings, industry, and transport, and how automation systems, smart grids, and data analytics contribute to enhanced energy efficiency and reduced emissions. The study examines exemplary global practices, such as Far EasTone's commitment to the RE100 Global Renewable Energy Initiative, aiming to transition to 100 % renewable energy usage across its facilities by 2040. Far EasTone Telecommunication is leveraging artificial intelligence to

optimize 5G base station selection and minimize power consumption while maintaining user satisfaction. The study underscores the extensive and wide-ranging impact of digital technologies on sustainable green development, enabling comprehensive data collection on environmental metrics like CO<sub>2</sub> emissions and water usage. Utilizing this data can inform better decision-making by businesses and governments to mitigate environmental impact. Digital technologies play a pivotal role in expediting innovation and ensuring efficient resource utilization for environmental preservation. Additionally, the RE100 Initiative, a global coalition of companies committed to sourcing energy exclusively from renewable sources, is discussed for its role in reducing carbon footprints and promoting sustainable energy transitions. The article analyzes fundamental principles of green sustainable management and highlights best practices in employing digital technologies for sustainable green development. Theoretical insights into the potential of digital technologies for sustainable green development contribute to the formulation and execution of practical initiatives to address global environmental challenges.

The chapter thoroughly examines both the theoretical underpinnings and practical applications of digital technologies in sustainable green development, positioning it as a valuable contribution to ongoing discourse in this field. The chapter analyses the impact of digital technologies on sustainable green development, in particular their role in increasing resource efficiency, reducing emissions and implementing circular economy models. International practices of using digital technologies to optimize energy consumption, environmental monitoring and environmental management are explored.

### **Keywords**

Digital technologies, sustainable green development, green management, international practices, environmental impact, RE100 Initiative, renewable energy sources, CO<sub>2</sub> emissions.

### **3.1 Introduction**

The significance of studying the impact of digital technologies on advancing sustainable green development lies in their ability to enhance the efficiency of renewable energy sources like solar panels and wind turbines. This is achieved through accurate weather forecasting, optimized system operations, and effective energy storage solutions. Furthermore, digital technologies contribute to more efficient resource utilization and support the adoption of circular economy models, where waste is transformed into valuable resources.

The relevance of this study is emphasized by several key factors:

**1. Climate change and environmental instability:** human activities have contributed to climate change and an increase in natural disasters, highlighting the urgent need for a balanced approach to sustainable development. Digital technologies can play a crucial role in reducing environmental impact through improved efficiency and smarter resource management.

**2. Digital technologies in green development:** the effective use of resources and reduction of emissions are essential for sustainable development. Digital technologies are critical to these efforts, supporting everything from monitoring environmental performance to optimizing production and transportation processes.

**3. Synergy as a driver for results:** the integration of digital technologies with green development initiatives can create powerful synergies, helping to achieve sustainable environmental outcomes. Understanding how these areas interact will uncover the most effective pathways to reach sustainability goals.

**4. Challenges of instability and the need for new approaches:** global instability, driven by factors such as economic crises and pandemics, creates new challenges for sustainable development. By studying the relationship between digital technologies and green development, it is possible to develop adaptive strategies that are resilient in the face of uncertainty.

The aim of this study is to analyze the best international practices on the role of digital technologies in sustainable development, with the goal of identifying how these technologies can support the achievement of sustainable green management.

The object of this study is the creation of a sustainable environment under conditions of instability, viewed as a multifaceted social, economic, and environmental phenomenon. The subject of the study is the impact of the synergistic interaction between digital technologies and green development in fostering a sustainable environment amidst instability.

The main tasks:

- to study the impact of digital technologies on reducing the negative impact of human activity on the environment by increasing resource efficiency and reducing emissions;
- to analyse international practices of integrating digital technologies into sustainable green development processes to optimise production, transport and environmental monitoring;
- to determine the synergistic effect of combining digital technologies and green initiatives as the main driver for achieving sustainable environmental results;
- to assess the impact of instability on green development processes and formulate recommendations for increasing the resilience of socio-economic and environmental systems through digital solutions.

These tasks allow to deepen our understanding of the interaction between digital technologies and green development, as well as to contribute to the creation of effective strategies to ensure a sustainable environment in the face of instability. By combining digital technologies with green development strategies, a substantial positive impact can be achieved, particularly in uncertain conditions. Instability, characterized by unpredictability and turbulence, arises from various sources such as economic crises, political upheaval, natural disasters, and technological or socio-cultural shifts. This instability affects multiple sectors, including business, politics, economics, society, and the environment. Responding to these conditions demands adaptability, flexibility, and the development of strategies that reduce risks and enhance resilience.

Digital technologies like the Internet of Things (IoT), real-time data analytics, and smart systems can effectively monitor and address environmental concerns such as air quality, water pollution, and climate change. Smart grids and automated processes can significantly reduce energy consumption, lowering greenhouse gas emissions and promoting more sustainable urban and industrial environments. By enhancing the efficiency and reliability of renewable energy sources, digital technologies help optimize power generation and storage, while waste management systems enable better recycling and resource use.

Furthermore, digital tools can raise public awareness on environmental issues, fostering sustainable consumption and behavior among individuals and businesses. This integrated approach will be essential in addressing the challenges posed by instability and ensuring a greener, more sustainable future. Mobile apps, online courses, and other digital resources can provide information and skills for conservation. They can work synergistically, reinforcing each other to promote sustainable environmental development, even in times of instability.

### **3.2 Research methodology**

The research employs a combination of system analysis and synthesis, Agile methodology, and a variety of other approaches, including axiological, synergistic, ecological, and humanistic methods. This methodological framework enables a comprehensive analysis of international best practices regarding the impact of digital technologies on sustainable development and facilitates the identification of how these technologies contribute to achieving sustainable green development. These approaches provide valuable insights into addressing environmental challenges and developing sustainable strategies for the responsible use of the planet's resources.

1. Ecological approach: this interdisciplinary method has evolved alongside environmental challenges and advancements in research, prioritizing environmental protection and the rational use of resources across all areas of human activity. The key principles of the ecological approach encompass international best practices for the role of digital technologies in sustainable development, strategic planning, reducing environmental impact, promoting resource recovery and recycling, increasing the use of renewable materials, managing waste, fostering social responsibility, and ensuring sustainable development.

The ecological approach is vital for preserving natural resources and ecosystems while promoting sustainable interactions between humans and the environment. It emphasizes the responsible use of resources and the interdependence of human and ecological systems.

In studying the impact of digital technologies on sustainable green development, this approach helps identify strategies to:

- use resources more efficiently;
- reduce emissions and pollution;
- increase energy efficiency;
- improve environmental management practices.

By adopting these principles, the ecological approach contributes to advancing both sustainability and the long-term protection of ecosystems.

2. The method of systematic analysis and synthesis is a powerful tool for combining various facts and best international practices into a system aimed at increasing resource efficiency and implementing circular economy models. This method allows for a comprehensive approach to resource and waste management aimed at maximizing their use and recovery. The main stages of the systematic analysis and synthesis method in this context may include: analysis of the current state; identification of key issues and challenges; analysis of international best practices; development of an integrated strategy; implementation and monitoring of existing practices. Assessment of current resource use and waste management in different countries and sectors. This includes collecting and analyzing data on resource use, waste volumes and the effectiveness of existing management models. Identify the main challenges and obstacles that hinder the efficient use of resources and the implementation of the circular economy. Research and analysis of best practices in resource and waste management from around the world. This may include successful projects, technological innovations, legislative and regulatory measures, etc. Develop a comprehensive strategy that combines best practices and innovations to increase resource efficiency and implement circular economy models. Implementing the strategy and continuously monitoring the results to identify opportunities for further

improvement. This method allows to take into account all aspects of the resource use and waste management system, creating an integrated approach that contributes to the goal of resource efficiency and sustainable use.

3. An axiological method based on the values of digital technologies for achieving sustainable green development as a factor of green sustainability; An axiological method that considers the values of digital technologies in the context of achieving sustainable green development can be based on the following aspects – defining values, assessing impacts, developing strategies. Digital technologies can stimulate innovation in solving environmental problems and contribute to the creation of a sustainable environment. An axiological analysis helps to identify the values that these technologies can embody, such as efficiency, environmental friendliness, innovation, etc. Digital technologies can have different types of impact on green development, including reducing emissions, optimizing resources, improving environmental monitoring, etc. An axiological approach allows to assess this impact in terms of the values of sustainability and green sustainability. An axiological analysis can help develop strategies for using digital technologies to increase their favorable impact on the sustainability of the environment. This can include prioritizing projects and initiatives that are most in line with green development values. An axiological approach can also help to take into account the ethical aspects of using digital technologies in green development, including issues of transparency, responsibility and justice. Thus, the axiological method allows for a deeper understanding of the value aspects of using digital technologies to achieve sustainable green development and develop strategies aimed at increasing their positive impact on environmental sustainability [1].

4. The synergistic method, which is based on self-organizing processes and the possibility of finding an attractor that can lead to synergy and overcome all the problems of the impact of digital technologies on achieving sustainable green development and environmental sustainability. A synergistic approach to the study of digital tools for the effective functioning of a sustainable ecological environment in conditions of instability, reflecting a new understanding of the analysis of complex systems, such as production systems, tax systems, ecological systems, using the tools of the synergetics methodology. According to this approach, the interaction of individual components of a complex system can lead to emergent properties and unexpected results that cannot be explained by analyzing each part of the system separately. When studying digital tools in the field of complex systems in a state of instability, the synergistic methodology is used to understand the interaction of different technologies, processes and participants in this system in order to reveal their impact on the overall result.

The synergistic method of studying this problem provides some important advantages and opportunities. The synergistic approach allows to consider the problem in the context of a complex system, taking into account the interconnections and interactions between its constituent parts. It helps to understand how digital technologies and green sustainable management interact with each other and with other elements of the system.

The synergistic approach allows to identify the emergent properties of a system – those that arise as a result of the interaction between its components.

It allows to identify unexpected or non-linear effects of digitalization in green sustainable management [2].

The synergistic method allows studying system changes over time and identifying key phase transitions or critical points when the system moves from one state to another. This helps to predict and manage changes in the system.

The synergistic approach allows for the inherent instability and nonlinearity of the system, which are characteristic of many complex systems. This helps to develop more effective change and risk management strategies. The synergistic method may include elements of various research methods, such as modelling, data analysis, expert opinions, and others. This allows for a comprehensive and in-depth analysis of the problem. The synergistic method of researching this problem provides an opportunity for a deep understanding of the relationships and interactions between digital technologies and green sustainable management strategies, which allows for the development of more effective and innovative approaches to their integration. The synergistic method involves an integrative analysis that takes into account the technical, social, economic and political aspects of using digital tools to analyze complex systems. interaction between different digital tools, socio-economic and political aspects of introducing digitalization into tax systems, as well as identifying potential risks and challenges.

5. The use of the Agile method in addressing the synergy of digital technologies and green sustainable management can have several advantages. The Agile approach allows for flexible adaptation of strategies and plans in line with changes in requirements, market conditions and technological capabilities. This is especially important in the case of complex innovation projects where digital technologies need to be combined with green sustainable management. The Agile method considers a project as a set of short iterations, each of which brings a specific result or functionality. This allows to quickly test hypotheses, experiment and make changes in the early stages of the project. The Agile approach promotes the active involvement of stakeholders in the development process, including experts in digital technologies and green sustainable management. This helps ensure that

the solutions developed meet the real needs and requirements of users. The Agile approach supports active communication and collaboration between project team members. This helps to solve complex problems through collective problem-solving and the exchange of ideas. Thanks to the iterative and flexible nature of the Agile approach, teams can quickly develop and launch new products or services. This minimizes time-to-market and allows to get feedback from users faster. In general, the use of the Agile method in addressing the synergy of digital technologies and green sustainable management allows to effectively solve complex problems and respond quickly to changes, ensuring high quality and compliance with market and consumer needs.

6. General philosophical methods – analysis and synthesis, generalization, comparison, which allowed to formulate the concept of the impact of digital technologies on achieving sustainable green development, optimizing energy consumption in buildings, industry and transport, creating smart grids and helping to use energy more efficiently and reduce emissions. "Eco-agriculture" based on a digital culture of green management. Thanks to the methods and approaches used, it is proved that the impact of digital technologies on achieving sustainable green development can be very significant and multifaceted. Digital technologies can help to implement monitoring and management systems that ensure the optimal use of resources such as energy, water and materials. The use of sensors and artificial intelligence systems to optimize production or transport system management can help reduce resource consumption and emissions. Overall, digital technologies can play a key role in achieving sustainable green development by helping to optimize resource use, reduce emissions and encourage environmentally conscious consumption [3].

Despite the significant potential of digital technologies in fostering sustainable green development, several unresolved issues remain:

1. *Inconsistent integration across sectors*: there is a lack of uniformity in the adoption and integration of digital technologies across various sectors and regions, leading to uneven progress in sustainability initiatives.

2. *Digital divide*: disparities in access to digital infrastructure, particularly in developing countries, hinder the global implementation of green development strategies.

3. *Data privacy and security concerns*: the increased use of digital tools raises concerns about data protection, privacy, and cybersecurity, which can impede the widespread adoption of these technologies.

4. *Uncertainty in measuring synergy effects*: the non-linear and emergent nature of the interaction between digital technologies and green management strategies presents challenges in quantifying their combined impact.

5. *Resource constraints and high costs*: implementing advanced digital solutions often requires substantial financial and technical resources, which can be a barrier for smaller enterprises or economically disadvantaged regions.

6. *Regulatory and ethical challenges*: the rapid evolution of digital technologies outpaces regulatory frameworks, creating gaps in governance, ethical standards, and accountability mechanisms.

### 3.3 Literature review

Based on the results of new research and practical findings, let's try to emphasize the importance of digital technologies that can help in implementing monitoring and control systems, ensuring optimal use of resources such as energy, water and materials. For example, the use of sensors and artificial intelligence systems to optimize production or transport system management can help reduce resource consumption and emissions. In this paper, let's rely on the research of V. Nikitenko, V. Voronkova, R. Oleksenko, H. Matviienko, O. Butkevych "Sustainable agricultural development paradigm formation in the context of managerial experience of industrialized countries" [4].

The authors rely on the applied aspects of this mechanism, that digital technologies such as solar panels and wind turbines are becoming more affordable and efficient due to continuous development. Data analytics and forecasting can help optimize energy production from renewable sources for the purpose of environmental protection and international legal protection what it is possible to found in the work of A. Getman, O. Danilyan, O. Dzeban, Yu. Kalynovsky, J. Crespo "International legal environmental protection: Historical aspect" [5]; O. Danilyan, O. Dzeban, Yu. Kalynovsky "Social instability as a global trend of the modern world" [6].

The analysis of the work by V. Nikitenko, V. Voronkova, R. Oleksenko, H. Matviienko, O. Butkevych "Sustainable agricultural development paradigm formation in the context of managerial experience of industrialized countries" [4] proved that the use of digital technologies such as blockchain can help track, recycle and recover resources within the circular economy, reducing waste and promoting sustainable use of resources. The work of N. Metelenko, I. Klopov, V. Voronkova, V. Nikitenko, R. Oleksenko, A. Brytvienko, N. Runcheva played a major role in our research "Development of flexible management structures in the context of digital transformation of industry 5G" [7] and T. Teslenko, V. Voronkova and M. Hakova "Green agro-production as a factor of competitiveness, sustainability, efficient and ecologically safe agriculture" [8]. The literature analysis shows that digital technologies can be a powerful

tool in achieving sustainable development, helping to reduce emissions, optimize resource use and promote environmentally conscious consumption [9].

Digital technologies, such as sensors, monitoring and data analytics systems, allow companies and governments to collect and analyze large amounts of information about energy and water consumption, CO<sub>2</sub> emissions and other environmental indicators. This helps to identify opportunities for efficient resource use and emissions reduction, which has been confirmed in the literature: M. Graham, R. Jorgen "In search of prosperity. Managing economic development to reduce unemployment, inequality and climate change" [3]; N. Klein "Everything changes. Capitalism against the climate" [10]; D. Meadows, J. Randers, D. Meadows "The limits of growth. 30 years later" [11]. An analysis of the literature has shown that the impact of digital technologies on achieving sustainable green development can be significant and multifaceted. Digital technologies can optimize energy use in various sectors such as construction, transport and industry. Remote control, intelligent building management systems and energy-efficient networks are just a few examples.

The literature and concepts analysis of the synergy of digital technologies and green sustainable management includes an overview of modern technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, data analytics, etc. and their possible impact on green sustainable management. Concepts such as digital transformation and others are used to understand and describe this impact. The literature review includes research into green sustainability strategies and concepts, such as the Sustainable Development Goals (SDGs), the circular economy concept, ESG (environmental, social, governance) principles, and others. These concepts point to the importance of environmental and social responsibility for businesses. The literature review helped to identify key links between digital technologies and green sustainable management. It can include the use of digital technologies to monitor and optimize energy consumption, production and logistics, as well as to improve resource efficiency and reduce emissions and waste [12].

The literature review helped to uncover innovative approaches and practices in using digital technologies to achieve green goals. This includes using blockchain to track the production chain, implementing smart energy and water management systems, and using artificial intelligence to analyze and predict environmental performance. The literature review revealed challenges and barriers to the integration of digital technologies and green sustainable management. These may include technological limitations, cost aspects, data privacy risks, as well as cultural and organizational challenges. Overall, the literature and concepts review allow to explore various aspects of the synergy of digital technologies and green sustainable management, opening up opportunities for further research and development in this area.

## 3.4 Results of the study

### 3.4.1 Areas of influence of digital technologies on sustainable green development

The impact of digital technologies on sustainable green development is extensive and multifaceted. Key areas of influence identified in the study include:

**1. Data collection and environmental monitoring:** digital technologies facilitate the collection of vast amounts of data on environmental indicators such as CO<sub>2</sub> emissions, water consumption, and more. Analyzing this data enables companies and governments to make informed decisions aimed at reducing environmental impact.

**2. Sustainable mobility:** the rise of electric vehicles (EVs), charging infrastructure, and ride-sharing mobile applications have contributed to lowering emissions and reducing fuel consumption. Smart transport systems, combined with GPS, routing data, and advancements in EV technology, further enhance the efficiency of transportation, leading to reduced emissions.

**3. Circular economy and resource management:** digital technologies play a crucial role in tracking and managing resource use within a circular economy. Blockchain and similar technologies provide transparency and reliability in resource recovery and recycling, supporting the shift to a sustainable resource loop.

**4. Public awareness and sustainable consumption:** information technologies promote environmental awareness by providing easy access to information about the environmental performance of goods and services. Social media and online platforms enable companies and organizations to advocate for environmentally conscious consumption, influencing consumer behavior towards sustainable choices.

**5. Geographic information systems (GIS) and environmental modelling:** GIS and modelling tools help assess the environmental impact of construction and infrastructure projects, aiding in the mitigation of negative effects and optimizing environmentally friendly solutions.

**6. Renewable energy optimization:** digital technologies improve the efficiency and reliability of renewable energy sources, such as solar and wind power, by using weather forecasting and data analytics to predict and optimize energy production.

**7. Waste management and IoT:** Internet of Things (IoT) systems allow for real-time monitoring and management of waste and resources, improving waste management practices and increasing recycling efficiency [13].

**8. Supply chain sustainability and ESG Data:** high-quality environmental, social, and governance (ESG) data is now essential for companies seeking to build trust in the market. The 2023 revisions of the Dow Jones Sustainability Indicators (DJSI)

and the Carbon Disclosure Project (CDP) emphasize the importance of sustainable supply chain management. Digital tools such as big data analytics and AIoT allow businesses to better monitor the sustainability performance of their supply chains, helping to identify risks early and make informed decisions.

**9. Sustainable enterprise development:** companies are increasingly incorporating digital sustainability tools into their operations to enhance sustainability actions and manage costs effectively. A truly sustainable enterprise integrates sustainability from the product or service source to the deployment of digital capabilities, supporting decision-making through effective data management.

**10. Green logistics and carbon reduction:** enterprises in the logistics sector are adopting smart technologies and innovative applications to reduce carbon emissions and enhance energy efficiency. Advanced technologies like AI computing, automatic identification systems, and modern mail processing equipment significantly improve operational efficiency and accuracy, contributing to greener logistics systems.

**11. Sustainable competitive advantage through ESG:** as businesses undergo digital transformation, ESG considerations are becoming a key competitive advantage. Companies that integrate sustainability into every decision, from production to logistics, can achieve long-term success while ensuring a positive environmental impact.

Overall, digital technologies are accelerating innovation and enabling more efficient use of resources to protect the environment. However, ensuring that these technologies are employed in a sustainable and socially responsible manner is critical to maintaining the balance between technological advancement and environmental preservation [9].

Back in 2021, the EU's Digital Europe Project Group proposed the concept of a "double transition", which includes harnessing the power of digital technologies to achieve corporate sustainability goals, including corporate greenhouse gas emissions reduction, service modernization, and strengthening corporate governance. The World Economic Forum's report notes that the use of digital tools will lead to a reduction in the trinity of global leaders in the energy, materials and transport sectors. As a result, emissions will reach the goal of reducing global carbon emissions by 20 %. This shows that the use of digital tools for sustainable development has unlimited potential. In recent years, digital management platforms have become an integral trend in the transformation of sustainable development, including resource efficiency, improving sustainability performance and supporting businesses in implementing sustainable strategic development. It is necessary to use new technologies that will help reduce carbon dioxide emissions and become an indicator of success. These technologies include:

1. Introduction of carbon-free hydrogen production.
2. Development of batteries capable of storing energy for the entire season for cities.

3. Use of electric fuels.
4. Improvement of biofuels.
5. Production of carbon-neutral cement.
6. Production of carbon-neutral steel.
7. Development of carbon-neutral fertilizers.
8. Use of new generation nuclear reactors.
9. Development of nuclear fusion.
10. Implementation of technologies for carbon capture directly from the air and point removal.
11. Development of underground power lines.
12. Production of carbon-neutral plastics.
13. Use of geothermal energy.
14. Implementation of hydroaccumulation.
15. Increasing the accumulation of thermal energy.
16. Development of carbon-neutral alternatives for palm oil.

To achieve these goals, it is necessary to:

1. Increase funding for clean energy and climate change research and development fivefold.
2. Focus on ambitious but risky research.
3. Develop cooperation with industry.
4. Build appropriate infrastructure.
5. Change the emissions pattern and recognize the right choice of trajectory.

If countries start taking action today, using the power of science and innovation, they have a chance to avoid repeating the mistakes of the past. The key is to embrace innovations that not only improve technologies and processes, but also reflect the possibility of new approaches to business models, supply chains, markets and regulation. This will help to realize ideas and implement them on a global scale. Innovations are new tools and ways of doing things that are already available to humanity, but achieving zero global emissions requires the combined efforts of all nations, as it is a global problem for.

### **3.4.2 Global climate change as one of the greatest challenges to humanity in the 21<sup>st</sup> century**

The study of the topic is that every day the economic progress of the world is accompanied by the aggravation of environmental problems. Air, water, and ocean pollution is increasing, threatening ecosystems and the survival of wild animals and

plants. The exploitation of forests and minerals poses a threat to humanity. Global climate change is having an unprecedented impact, altering weather patterns and increasing the risk of catastrophic events that threaten food production and increase flood risk. Adapting to these changes will be more difficult and costly in the future if urgent action is not taken now. Global climate change is one of the greatest challenges of the 21<sup>st</sup> century. The use of carbon-based energy, such as coal and oil, meets needs but causes climate change. Immediate action by countries and governments is needed to address this issue. Transitioning to a low-carbon climate is a challenge that encompasses climatic, political, technical, economic, environmental, social, ethical and security aspects [6].

To address global climate change and reduce greenhouse gas emissions, a wide range of technologies must be used:

1. Solar, wind, hydro, tidal and natural gas can replace coal and other fossil fuels. The use of these energy sources helps to reduce greenhouse gas emissions.

2. Energy efficiency, which is based on reducing energy use through more efficient technologies and methods of energy consumption, can significantly reduce CO<sub>2</sub> emissions.

3. Carbon capture and storage (CCS), which allows carbon dioxide to be removed from industrial plant emissions and stored in underground tanks, reducing emissions.

4. Green building, which is based on the use of energy-efficient materials and design, the installation of photovoltaic elements on roofs and the use of other energy-efficient systems can help reduce energy consumption in the construction and operation of buildings.

5. Electric vehicles, which aims to shift to electric cars and public transport, which can reduce oil use and reduce carbon dioxide emissions from motor vehicles.

6. Forest protection and growth, as forests play an important role in absorbing carbon dioxide. Preserving forests and increasing their area can help reduce carbon dioxide in the atmosphere.

7. Increasing environmental education and awareness, aimed at raising public awareness of global climate change and promoting environmental initiatives, can lead to changes in consumer habits and support for environmental policies. These technologies, when used together, can help combat global climate change and reduce greenhouse gas emissions.

One of the main means of addressing these issues is the Kyoto Protocol, which has the status of a legally binding document. It sets emission reduction targets that developed countries must meet. This protocol includes two commitment periods: from 2008 to 2012 and from 2013 to 2020. As of today, 198 parties to the Climate Change Convention are bound by the Kyoto Protocol, which means that

192 countries are signatories. In 2015, the 21<sup>st</sup> session of the Conference of the Parties to the Convention on Climate Change took place in Paris, during which the Paris Agreement was signed.

The Paris Agreement is a historic event, as it unites all countries of the world for the first time to achieve a common goal – to combat climate change. It provides for decisive measures to reduce emissions and adapt to the effects of climate change, in particular by attracting more support from developing countries. The main goal of the Paris Agreement is to keep the global temperature rise within 2 °C compared to pre-industrial levels and to limit the temperature increase to 1.5 °C. This agreement sets a new course for global climate action aimed at strengthening the global response to the threat of climate change [10].

In today's world, growing threats and disasters are forcing to address the well-being and security of all people as never before. This topic not only unites under unprecedented pressure, but also creates unique opportunities and motivation for change. Countries with large carbon emissions must actively work to reduce their carbon footprint. This can be done by developing sustainable development strategies that focus on energy conservation and emissions reduction. This includes energy efficiency, optimization of the energy mix and other measures. In terms of technology, it is important to develop energy-saving technologies and the use of renewable energy sources.

Investing in clean and efficient technologies will help reduce our dependence on fossil fuels and reduce greenhouse gas emissions. It is important to reduce the cost of clean energy and make it accessible to all. Through the full implementation of scientific developments and technological innovations, it is possible to achieve control over climate change and ensure the well-being and security of all people.

Greenhouse gases from human activity play an important role in providing the heat on Earth that is necessary for life. However, following industrialization, deforestation and large-scale agriculture, the amount of greenhouse gases in the atmosphere has reached levels not seen in millions of years. Population growth, economic development and rising standards of living lead to an increase in greenhouse gas emissions. The concentration of these gases in the atmosphere has a direct impact on the global average temperature. The most common of these gases is carbon dioxide, which is produced mainly by the combustion of fossil fuels. In recent years, there have been significant changes in the climate system, such as weather instability and other anomalies that have not been seen for centuries or even millennia. This indicates the need for immediate measures to reduce greenhouse gas emissions and minimize the negative impact on the Earth's climate system.

Climate change, induced by human activity and extreme weather events, has already led to a number of disasters, such as heat waves, heavy rainfall, droughts and

tropical cyclones, in different parts of the world. Approximately 3.3–3.6 billion people live in areas vulnerable to climate change. If global temperatures remain above 1.5 °C, many human communities and ecosystems will face significant risks. Reducing greenhouse gas emissions across the energy sector requires significant changes, such as a rapid reduction in the use of coal and other fossil fuels, a shift to low-emission energy sources, and increased energy efficiency and conservation. Scientific evidence suggests that the Earth's ecosystems and climate system may be on the verge of, or have already passed, important tipping points that could lead to irreversible.

Various ecosystems, such as the Amazon rainforest and the Arctic tundra, are currently experiencing severe changes due to warming and drought. To limit global warming to 1.5 °C, rapid and profound transformations are needed in a variety of areas, including land use, energy, industry, construction, transport and urban planning. By 2030, global carbon dioxide emissions should be reduced by around 45 % compared to 2010 levels, and by 2050 they should be almost zero. This means not only reducing emissions, but also removing carbon dioxide from the atmosphere to balance the remaining emissions. Climate change can be caused by both natural internal processes and external influences, but anthropogenic factors such as changes in the composition of the atmosphere and land use play a major role in modern climate change. These changes have been observed for a long time and have serious consequences for ecosystems and life on the planet.

The greenhouse effect is the process of thermal insulation of the atmosphere, which occurs due to the trapping effect of greenhouse gases and leads to global climate change. There are several types of greenhouse gases on Earth, but the main ones are water vapor, carbon dioxide, methane, nitrous oxide, perfluorocarbons and sulphur hexafluoride. The total contribution of water vapor to the greenhouse effect is about 60–70 %, and carbon dioxide is about 26 %. Carbon dioxide is considered the most important greenhouse gas because of its long-term presence in the atmosphere, which can last up to 200 years. Even if carbon dioxide emissions stop today, the effect of previous emissions will be felt for the next two centuries [14].

Carbon dioxide is the result of both natural and human activity, and its impact on the climate is significant. Since the Industrial Revolution, human production has indeed reached unprecedented levels, leading to significant changes in the natural environment. Efforts to limit greenhouse gas emissions are indeed at the heart of the future international climate regime. Recent years have shown that more and more countries are realizing the need for sustainable development that meets social needs without endangering future generations. The transition from carbon-based energy to clean energy sources is becoming a key principle in modern energy construction. We, as a society, are not only facing the consequences of historical pollution in other

countries, but also have the right to develop today while ensuring a responsible attitude towards the future of our descendants [7].

The development of new renewable energy technologies and energy-efficient systems is becoming a critical step in reducing environmental pollution. The energy challenges are global, and the transition to new energy sources is inevitable.

All developed countries, which primarily relied on carbon-based energy sources, have gone through a period of high carbon dioxide emissions. Today, almost 90 % of the world's primary energy consumption depends on three main fossil sources: oil, coal and natural gas. However, 70 % of primary energy consumption is based on coal, which is a seriously polluting source and emits significant amounts of carbon. There is an urgent need to adjust the energy mix, reducing dependence on coal and other carbon-intensive sources and promoting a transition to clean and sustainable energy sources [15].

Currently, coal power remains the largest source of energy, determining the absolute dominant position in the energy mix. However, China is taking decisive measures to effectively control air pollutant emissions, especially from thermal power plants. The country is developing clean power generation technologies, reducing coal consumption for electricity generation, eliminating outdated production facilities, increasing energy efficiency and reducing emissions. The closure of small thermal power units and the promotion of restructuring of the electricity sector have yielded significant results. The use of wind energy is also important, especially for remote regions where other energy sources may not be available. Today, solar energy is considered to be the most ideal substitute for coal energy, as it has become a reliable and efficient source of energy without having a significant impact on the environment.

The benefits of using solar energy are enormous:

1. Sunlight is available almost everywhere and has no geographical restrictions. The production and use of solar energy can be carried out locally, which reduces the need for transportation.
2. The use of solar energy is not accompanied by emissions of harmful substances and does not pollute the environment. This reduces dependence on energy sources that have a harmful impact on the environment.
3. Solar radiation is a limitless source of energy that can be used without restrictions. Its potential exceeds the needs of modern society and can provide energy for future generations [14].
4. Solar energy reserves are infinite compared to other energy sources. The sun will continue to emit energy for tens of billions of years, making solar energy a reliable and long-term source of energy. Although there are disadvantages, such as solar radiation scattering, which reduces the efficiency of energy use, the benefits of solar

energy outweigh the disadvantages, making it one of the most attractive and environmentally friendly energy source.

Despite its advantages, solar energy also has its disadvantages:

1. A large area of photovoltaic elements or collectors is often required to generate a certain amount of solar energy conversion power, which can be costly in terms of equipment and installation.

2. Solar energy is not a stable source of energy due to the influence of weather conditions such as clouds or rain. This can make it less efficient and impractical for some areas or applications.

3. Storing solar energy for use when the sun is not shining is challenging. Currently available technologies for storing solar energy, such as batteries, can be expensive and not very efficient.

4. Some devices for collecting and using solar energy may have low efficiency and high cost, making them uncompetitive with other energy sources [16].

The development of technologies to overcome these obstacles is key to the further deployment of solar energy as a clean and efficient energy source. According to the latest data, solar energy production has the potential to become a key source of energy for the future. Although the cost of this technology is currently relatively high, with the development of technology, its production may become more affordable. This will pave the way for the large-scale use of solar energy and contribute to the development of a low-carbon economy. Climate change poses a serious threat to global food security, poverty alleviation and sustainable development. It is important that all sectors, including public and private financial institutions, commit to promoting a green economy. This will help reduce global greenhouse gas emissions and address climate change. The next decade is critical for reducing greenhouse gas emissions. In order to limit global warming to 1.5 °C by 2030, emissions must be reduced by 45 %. This will require significant efforts from governments, industry and society as a whole.

The synergy of digital technologies and green development can play a key role in addressing these challenges. Digital technologies, such as satellite observation, sensor networks and big data analytics, can help collect and analyze information on climate change. This will allow for a better understanding of the causes and impacts of climate change and more effective decision-making on how to manage it.

The use of digital technologies to optimize energy production and consumption can help reduce greenhouse gas emissions and natural resource consumption. For example, smart energy and grid management systems can automatically adjust electricity consumption depending on needs and conditions.

The development of renewable energy sources, such as solar and wind power, is helping to reduce greenhouse gas emissions and dependence on hydrocarbons.

Digital technologies can help in the efficient deployment of these energy sources and the management of energy systems [17].

Digital technologies can help to implement systems and infrastructure for climate change adaptation, such as water purification systems, flood defenses and other measures to reduce the risk of climate disasters.

Digital technologies can stimulate cooperation between sectors and countries in developing and implementing innovative solutions to reduce the impact of climate change.

Thus, the synergy of digital technologies and green development can significantly improve our ability to address the challenges of global climate change by providing more effective and innovative solutions.

### **3.4.3 Implementing a green strategy in the context of the ESG (environmental, social, governance) paradigm**

Implementation of a green strategy in the context of the ESG (Environmental, Social, Governance) paradigm is the practice of planning and managing the urban environment to ensure sustainable development, protect the environment and improve the quality of life of residents. The main goals of a green urban development strategy include:

1. Conservation of natural resources, which includes reducing energy and water consumption, rational use of land and biodiversity, and encouraging the use of renewable energy sources.
2. Reducing emissions and pollution, which includes minimizing emissions of harmful substances into the atmosphere, water sources and soil, and promoting the use of clean technologies and environmentally friendly modes of transport.
3. Improving the quality of the environment, including increasing the number of green areas, parks, squares and other urban landscapes that contribute to improving air quality, deepening groundwater and maintaining biodiversity. Stimulating an environmentally friendly lifestyle, which includes promoting and supporting environmentally conscious habits and consumer behavior, and developing public transport, pedestrian and bicycle paths.
4. Ensuring sustainable economic growth aimed at developing green technologies and economic sectors related to environmental protection and sustainable development, as well as creating new jobs in green industries. Green urban development is aimed at creating a harmonious and environmentally balanced and synergistic urban environment that meets the needs of the current population without harming future generations [18].

The transformation of green urban development plans can include various strategies and initiatives to preserve the environment, reduce emissions, improve air and water quality, promote the conservation of natural resources and use green technologies. Improving the energy efficiency of buildings can include promoting the use of green technologies in construction, such as photovoltaic systems, energy-efficient heating and air conditioning systems, building insulation and other methods. Promoting the use of public transport can help reduce car emissions and traffic congestion, and include expanding the public transport network, promoting the use of bicycles and pedestrian paths. Increasing the number and area of green spaces in the city will help improve air quality, reduce temperature differences and improve the overall comfort of residents. Developing waste management systems, material recovery and recycling can help reduce the amount of waste going to landfills and reduce the negative impact on the environment. Promoting environmental education and awareness, including developing programmes for residents and businesses to live greener and support sustainable practices, can help to preserve the environment and increase environmental awareness. These examples are just a few of the possible green urban development strategies that can be used to improve the quality of life of residents and preserve the environment.

The following cities stand out in the context of implementing the green ESG (Environmental, Social, Governance) paradigm. Singapore (city-state) is renowned as one of the most densely populated and greenest cities in the world. It is known for its innovations in green building and environmental design. The city is actively promoting its 2030 Green Development Plan, which aims to improve the quality of life for residents and reduce greenhouse gas emissions. Singapore is also a leader in sustainable tourism, striking a balance between environmental protection and economic stability. New Taipei (Taiwan) is known for its green environment and natural beauty. A large number of parks and green areas throughout the city contribute to the active use of these areas for recreation, sports and education. New Taipei actively develops and supports environmental initiatives such as green buildings, recycling programmes and energy efficiency. An extensive public transport system and bicycle paths help reduce traffic congestion and carbon emissions. Both of these cities show a strong interest in green development and sustainable environmental solutions, making them examples for other cities around the world [11].

Some countries are actively working to preserve the natural environment and implement sustainable development strategies and green technologies. Here are some examples: Copenhagen is known for its bike lanes, parks, and CO<sub>2</sub> reduction initiatives such as the Copenhagen Climate Plan programme. Curitiba has one of the best public transport systems in the world and many parks and green spaces for

residents. Portland is actively working to create a sustainable city, with many bike paths, parks and energy efficiency programmes. Malmö is known for its innovations in energy efficiency and renewable energy, such as green building facilities and wind turbines. Wellington has a large number of green spaces and parks, and actively encourages the use of public transport and green technologies [19]. Stockholm has an impressive amount of green space that includes parks, forests and lakes, creating natural oases in the middle of the city, and is actively implementing energy-efficient technologies and working to reduce CO<sub>2</sub> emissions. Freiburg is known for its environmental awareness and developed renewable energy system, and has a large number of bike paths and pedestrian areas, promoting an active lifestyle. Amsterdam is known for its cycling culture and the green corridors that run through the city. A well-developed public transport system adds to the convenience of residents, and many parks and squares add a touch of green to the city. Kyoto is renowned for its traditional Japanese gardens and green spaces, reflecting the city's natural beauty and tranquility. It is also home to energy efficiency and renewable energy initiatives. Both of these cities have demonstrated their commitment to sustainable development and nature conservation, serving as excellent examples for other cities around the world.

To create a livable and sustainable zero-emission future, the New Taipei City government held the International Forum on Zero Emission Transformation 2023 to Create a Sustainable Home, inviting experts from around the world. The government is actively working to implement the zero-emission city model, waste reduction and energy conservation, which is contributing to the rapid transformation into an international zero-emission city. In addition, the New Taipei City government has made continuous efforts in the areas of gender equality, labor rights and housing justice. The city's leadership is always innovating and pushing the envelope, bringing innovative thinking and working methods to government departments. This has helped to achieve outstanding achievements in the Sustainable Development Goals and gender equality, and to actively engage in the international arena to achieve these goals. New Taipei City Government's efforts were recently recognized by the 2023 Asia Pacific and Taiwan Sustainable Development Action Award and the "Great City" award [4].

In the context of implementing a green strategy, the Sustainable Development Goals (SDGs) and the ESG approach (Environmental, Social, Governance) are important for ensuring sustainable transformation of the urban environment, which aim to achieve a sustainable society by addressing environmental, social and governance issues, although they differ in terms of their functions and scope. The SDGs are an updated version of the Millennium Development Goals launched by the UN in 2000.

Its goal was to successfully eradicate poverty and hunger, promote basic education, advance gender equality, reduce child mortality, improve health and combat AIDS within 15 years. These 17 Sustainable Development Goals apply to all countries and encompass business, local governments and civil society. The SDGs emphasize the inextricable link between the Sustainable Development Goals, which are based on cross-sectoral integration and cooperation between countries, governments, businesses, civil society groups and individuals. Despite the fact that the SDGs are not legally binding, many companies are taking the initiative to implement them and incorporate them into their business strategies. The ESG approach (Environmental, Social, Governance) assesses the environmental, social and corporate aspects of a company's operations. It is an important tool for investors and businesses to identify and assess environmental, social and governance risks and to implement more sustainable and resilient practices. ESG criteria help companies to focus on sustainability and responsibility in their operations, as well as to meet the requirements of social responsibility and environmental standards. Both SDGs and ESGs play an important role in promoting sustainable urban development and ensuring a resilient future [20].

ESG is an acronym made up of the first letters of three English words: Environmental, Social and Governance, and is used to assess and manage risks related to the environment, social aspects and corporate governance.

Environmental includes an assessment of the environmental impact of the company's operations. It covers energy and water use, waste management, climate change and other environmentally relevant issues.

Social aspects assess the company's interaction with society, employees, customers and other stakeholders. It may include issues related to employee rights, equality, safe working conditions, community development and other socially important aspects.

Governance assesses a company's governance systems and corporate leadership. It includes questions about the governance structure, corporate ethics, anti-corruption, and openness and transparency in decision-making.

Together, these three components help companies and investors to assess the overall impact of their business on the environment and society, and to ensure that their operations are sustainable and responsible.

ESG investing is a growing trend in the financial world, as more and more investors believe that a balanced focus on environmental, social and governance aspects can improve the long-term sustainability and return on their investments:

1. Environment covers the reduction of carbon emissions and the protection of the environment. Investors take into account environmental aspects such as the impact of companies on the climate and the conservation of natural resources [21].

2. Social refers to improving the working environment, promoting diversity and other social aspects. Investors care about the impact of companies on society, including the issues of employees, consumers and other stakeholders.

3. Governance refers to fair and transparent management and proactive disclosure. Investors analyze how companies are governed, their corporate ethics and anti-corruption practices.

ESG aims to assess the risks of sustainable urban development, explore opportunities for risk control and readiness to respond to climate change, epidemics and social turbulence. Investors are also looking at zero-carbon supply chain achievements and water management, assessing companies' readiness for the environmental and social challenges of the future.

Indeed, analysis suggests that the worsening climate crisis could have a significant impact on financial markets in the long term. It is predicted that changing climate conditions will lead to radical changes in the world order, and this will require corporate organizations to adapt to new realities. In particular, they will have to respond to political and economic changes, while at the same time stabilizing their sustainable development strategies.

The adoption of the Taiwan Climate Change Response Act in 2023 is an important step in this direction. The law sets ambitious targets, such as achieving zero emissions by 2050, and introduces regulations, such as carbon pricing, to help reduce negative environmental impacts. Corporations will have to proactively define their position and develop strategies to meet the requirements of the new legislation and adapt to the changing climate. In light of these developments, corporate organizations are encouraged to actively pursue ESG strategies to ensure their future sustainability and respond to the challenges posed by climate change and increased environmental risks [22].

Indeed, the carbon issue is becoming increasingly important and influencing corporate sustainability strategies. In order to ensure a more sustainable and systematic sustainability plan, the relationship between internal and external governance must be actively considered. Thus, it is important to understand that environmental, social and governance aspects are interconnected in the process of sustainable development and transformation of enterprises. Integrating these aspects into management strategies will allow businesses to cope more effectively with the challenges posed by climate change and increasing environmental risks and ensure sustainable development in the future.

Changing the sustainability cycle in 2024 is crucial, as only about 15 % of the goals are on track. The onset of the "global boiling point" announced by UN Secretary-General Antonio Guterres requires cities to accelerate the transition from the

Net Zero initiative to discuss real strategies and solutions. It also means refocusing on social aspects, the "S" in ESG, and equity [4].

The European Union's adoption of the Green Claims Directive and the introduction of strict rules on "eco-friendly" claims on UK product labels demonstrate the growing focus on environmental issues and the need for transparency in the marketplace. The introduction of carbon dioxide emission reduction targets demonstrates the growing awareness of companies of the need to take concrete steps to reduce their impact on the climate. It is a very important step towards achieving a more sustainable and environmentally conscious world. Synergy analysis does indeed reflect important trends in the field of sustainable development and climate change. This shift from consciousness to action is indeed reflected in various sectors of society, from governments to businesses and civil society organizations, and the implementation of sustainable development requires to constantly deepen our understanding and find new ways to achieve goals in the context of the synergy of digital technologies and green development and their impact on achieving a sustainable environment in an uncertain world.

Thus, the synergy of digital technologies and green development is manifested in the implementation of a green strategy in the context of the ESG (environmental, social, governance) paradigm as follows. Digital technologies allow collecting, analyzing and using large amounts of data related to environmental and social indicators. This helps companies develop effective green development strategies, taking into account the impact of their activities on the environment and society [23].

The use of digital technologies such as the Internet of Things (IoT), artificial intelligence and data analytics can improve energy efficiency and reduce emissions. For example, smart energy management systems can optimize energy consumption and reduce waste. Digital technologies are driving innovation in green technologies and the development of environmentally friendly products and services. This can include the development of new energy-efficient technologies, the use of renewable energy sources and waste reduction. Digital technologies allow companies to collect and analyze data on their environmental and social responsibility and make this information available to stakeholders. This increases the transparency of companies' operations and helps to improve the management of environmental and social risks. Digital technologies can be used to involve stakeholders in decision-making and planning of green development strategies. This can include using online platforms to communicate with stakeholders and collect their feedback and ideas.

Overall, the synergy of digital technologies and green development allows companies to more effectively implement green strategies in the context of the ESG paradigm, which contributes to the creation of more sustainable and environmentally friendly business models [8].

### 3.4.4 International practices of companies in achieving sustainable green development

Far EasTone is a leading telecommunications operator in Taiwan. Joining RE100 is an important step in reducing their carbon footprint and contributing to a more sustainable development. The RE100 initiative is a global platform that brings together companies from around the world who are committed to using exclusively renewable energy sources for their operations. RE100 members are committed to reducing their carbon footprint and contributing to the transition to a more sustainable energy system.

Some key RE100 initiatives include:

- 1) commitment to 100 % renewable energy: companies that join RE100 commit to achieving 100 % renewable energy for their operations within a specified timeframe;
- 2) collaboration and knowledge sharing: RE100 members share experiences and best practices in the use of renewable energy sources, which helps to spread these practices in the business environment;
- 3) supporting sustainable development: RE100 members demonstrate their commitment to sustainable development and reducing their impact on climate change through the use of clean energy;
- 4) influencing policy: by bringing together large companies and committing to 100 % renewable energy, the RE100 initiative can influence policy development and create favorable conditions for the development of clean energy;
- 5) visibility and leadership: companies that join RE100 act as leaders in the transition to renewable energy, which can encourage other companies to make similar commitments. The RE100 initiative has a significant impact on promoting sustainable development and reducing climate change impacts by accelerating the transition to renewable energy in large corporations and companies.

It can also serve as an example for other companies in the telecoms industry and other sectors to switch to cleaner energy sources.

To achieve the zero-emission sustainability goal, Far EasTone continues to develop environmentally friendly information and communication technologies through technological innovation. They are implementing low-carbon operations, collaborating with value chain partners and corporate customers to move towards sustainability together [8].

RE100 is a global initiative that brings together leading companies from around the world who are committed to using exclusively renewable energy sources for their operations. Far EasTone's joining RE100 means that they have committed to switching to exclusively renewable energy sources for their needs.

To accelerate the transition to zero net energy, Far EasTone has joined the RE100 Global Renewable Energy Initiative, committing to use 100 % renewable energy in all IDC computer rooms, offices and stores in Taiwan by 2030 and to achieve full use of renewable energy across the company by 2040.

Far EasTone Telecommunication is committed to building the most environmentally friendly telecommunications network. The company is using artificial intelligence to select 5G base stations to maximize network efficiency and is introducing technology to effectively reduce base station power consumption without compromising user experience.

Far EasTone is the first telecoms operator in Taiwan to join the Global Plan for the Recycling of Telecommunications Equipment for Environmental Protection. The recycling rate of base stations will reach 98 %, effectively reducing e-waste and allowing everyone to enjoy the quality of the 5G network while considering sustainability and environmental protection. Far EasTone is actively investing in environmental protection and greenhouse gas emission reduction through technological innovation to help enterprises with one-stop smart management capabilities. In addition, the company is investing in the construction of remote microgrids, uninterruptible power supply systems for traffic signs, universal intelligent control systems, and 5G remote diagnostics to create a sustainable smart city [24].

Far EasTone's efforts are aimed at creating an environmentally friendly, sustainable and innovative telecommunications network that demonstrates their commitment to environmental protection and the development of a sustainable society. Through the use of advanced technologies such as artificial intelligence and remote diagnostics, the company is developing in an environmentally friendly way, reducing its environmental impact and promoting sustainable development. In summary, the integration of digital technologies into companies' operations is becoming a key factor in achieving sustainable development [25].

Far EasTone is an example of a company that actively uses these technologies to ensure efficiency, sustainability and innovation in its operations, contributing to the preservation of the environment and the development of a sustainable society. Humanity will ultimately follow the path of "digital sustainability" as it will have a profound impact on the future development of humanity. Some companies propose to add digital technologies as the SDG 18, as digital advancement and the original 17 goals are interconnected. For example, digital transformation impacts employment opportunities, the digital divide exacerbates social inequality, remote learning can bridge the educational resource gap in rural areas, smart grids can enhance the resilience of key institutions, and digital healthcare can improve human health and well-being. Therefore, it is essential to comprehensively study the potential

impact of digital development on humanity's sustainability, and digital evolution itself should also incorporate the concept of sustainability.

Digital resilience can be defined as the integration of virtual and real systems, fostering innovative viability, continuously advancing digital transformation, and practicing social, economic, and environmental sustainability to create a sustainable future for humanity [2].

Here are examples of companies that have joined the RE100 initiative:

1. Google: this tech giant has committed to using 100 % renewable energy for all its operations and data centers.
2. Apple: Apple has also joined RE100 and announced its goal to transition entirely to renewable energy sources for all its factories, offices, and data centers.
3. Microsoft: Microsoft has committed to achieving 100 % renewable energy usage for its operations and software production.
4. IKEA: the Swedish retail company produces and uses its own renewable energy, such as wind and solar, for residential construction and its stores.
5. Inditex: one of the world's largest clothing manufacturers, known for brands like Zara, has pledged to use 100 % renewable energy for all its operations by 2025.

These companies are just a few examples among many organizations that have joined RE100, committing to reducing their carbon footprint through the use of renewable energy. Joining RE100 signifies their pledge to operate using energy generated from renewable sources such as solar, wind, water, and other inexhaustible sources. This commitment is a significant step for these companies in reducing their carbon emissions and promoting sustainable development. They recognize the importance of transitioning to clean energy sources to protect the environment and mitigate climate change [26].

Achieving synergy between digital technologies and green development requires a comprehensive and systematic approach. A key step is defining common goals for both areas – digital technologies and green development. This can include reducing carbon emissions, improving energy efficiency, and protecting biodiversity.

Implementing modern digital technologies, such as the Internet of Things (IoT), data analytics, and artificial intelligence, for the collection, analysis, and monitoring of environmental data will help understand the effectiveness of environmental measures and uncover new opportunities for green development [27].

Creating incentives for the development and implementation of innovative solutions that combine digital technologies and green development can include financial support, competitions, startup incubators, and other initiatives. Establishing partnerships between digital technology industries and green businesses will facilitate

knowledge and experience exchange, allowing for joint development and implementation of initiatives aimed at reducing environmental impact.

Raising awareness among the public, businesses, and government structures about the benefits of synergy between digital technologies and green development will help engage more participants in this process and support the creation of a favorable environment for these initiatives to grow.

All these steps will contribute to fostering an effective synergy between digital technologies and green development, leading to the creation of a sustainable and eco-friendly future. These examples show that companies from various industries recognize the importance of adopting responsible, sustainable practices and are taking steps to reduce their carbon footprint by switching to renewable energy sources.

International company practices in achieving sustainable green development can provide valuable insights for Ukraine. Many global companies are taking measures to reduce emissions and resource usage, which helps decrease their environmental footprint. Ukrainian companies can prioritize responsible production and resource management approaches. International companies are actively adopting renewable energy sources, such as solar and wind power, to reduce their carbon footprint and dependency on fossil fuels. Given Ukraine's strong potential in wind and solar energy, there are significant opportunities in this area [28].

*Companies are also embracing the principles of the circular economy, aimed at minimizing waste and maximizing resource use. This can include waste recycling, reducing packaging use, and producing more durable goods. Furthermore, businesses are developing strategies to adapt to climate change, as their operations may be at risk due to its impacts. This includes taking measures to mitigate climate-related risks and ensuring the sustainability of raw material supplies.*

Many international companies adhere to global sustainability standards, such as ISO or the UN Global Compact. These helps ensure high standards of environmental and social responsibility.

It is crucial for Ukrainian companies to consider these international practices and incorporate them into their operations to achieve sustainable green development. This approach will not only reduce the negative environmental impact but also ensure competitiveness and stability in the long term [29].

Some examples of practical applications of digital technologies can be incorporated, among them:

1. *Google's use of Artificial Intelligence for renewable energy optimization.*

Google applies advanced AI algorithms to predict energy demand and optimize the use of renewable energy sources in its data centers. For instance, its AI-driven system predicts weather patterns to determine the most effective times to store

and utilize solar and wind energy. This approach has enabled Google to achieve 100 % renewable energy usage across its operations while minimizing costs and energy waste.

*2. Microsoft's carbon negative initiative and IoT solutions.*

Microsoft has committed to being carbon negative by 2030 and employs IoT technologies for efficient resource management in its buildings. Smart IoT sensors track real-time data on energy and water usage, allowing for precise adjustments and reducing wastage. Additionally, Microsoft's AI solutions help businesses worldwide optimize energy consumption and minimize emissions.

*3. IKEA's circular economy platform and digital solutions.*

IKEA integrates digital solutions to promote its circular economy initiatives, such as its buy-back and resell program for furniture. Digital tracking systems monitor the lifecycle of products, helping reduce waste and encourage recycling. The company also uses blockchain to ensure transparency in its supply chain, focusing on sustainable sourcing and waste minimization.

*4. Tesla's smart grid and energy storage systems.*

Tesla has revolutionized renewable energy integration with its digitalized Powerwall and Powerpack systems. These systems enable smart grids to store surplus renewable energy and distribute it efficiently during high-demand periods. Coupled with real-time data analytics, Tesla's solutions reduce energy loss and improve the sustainability of energy grids.

*5. Siemens' smart cities initiative.*

Siemens leverages digital technologies, including IoT and AI, to optimize urban infrastructure for sustainable green development. The company's smart building systems monitor energy use and automatically adjust settings to minimize consumption. Additionally, Siemens provides digital platforms for managing smart grids, improving energy efficiency, and integrating renewable energy into urban areas.

*6. Unilever's digital water management solutions.*

Unilever uses advanced digital tools to monitor water usage across its production facilities. With IoT sensors and AI analytics, the company has significantly reduced water consumption and improved its wastewater recycling processes, contributing to more sustainable manufacturing.

These examples not only demonstrate the diversity of digital technologies being used globally to achieve sustainable green development but also highlight their practicality and scalability.

Ukrainian companies can adopt and adapt these practices to local contexts, focusing on renewable energy, resource efficiency, and waste reduction to foster long-term sustainability.

### 3.4.5 Key principles for implementing green sustainable management strategies

"Green sustainable management" is a business management approach that combines strategic planning, management practices, and innovative solutions to achieve sustainable development while minimizing negative environmental impact.

Principles in **Table 3.1** align with the core tenets of green sustainable management and contribute to fostering a more sustainable and responsible business environment. In essence, green sustainable management aims to strike a balance between environmental, social, and economic responsibilities to support sustainable development.

**Table 3.1 Key principles of green sustainable management**

No.	Principle	Contents and development direction
1	Environmental responsibility	Green management aims to reduce waste, use renewable energy sources and conserve resources
2	Social responsibility	Companies practicing green management pay attention to social aspects such as employees, communities and general well-being
3	Economic efficiency	Green management also aims to reduce costs, optimize processes and create new opportunities for sustainable development, leading to economic benefits
4	Innovations	Green management promotes innovation in production, technology and management to ensure more efficient use of resources and reduce environmental impact
5	Long-term perspective	Green management takes into account the long-term consequences of its actions and makes decisions aimed at preserving resources and sustainable development in the future
6	Transparency and reporting	Companies applying green management report on their sustainability actions and achievements to ensure transparency with stakeholders and consumers
7	Effective risk management	Green management takes into account potential environmental and social risks in its strategy and activities, and develops mechanisms for their management to prevent negative consequences
8	Involvement of interested parties	Green management takes into account the opinion and interests of various stakeholders, such as customers, employees, shareholders and public organizations, in the decision-making process
9	Environmental innovation	Green management stimulates the search and development of new environmentally friendly technologies, products and services that contribute to reducing the impact on the environment
10	Training and development	Companies that practice green management provide training opportunities for their employees on the principles of sustainable development and environmental responsibility

Source: developed by the authors

It ensures that both public and private sectors remain operational in the face of various changes, including the introduction of new commercial and public services, protection of critical assets, and the rapid accumulation of digital resources like data and NFTs. Therefore, leveraging digital technologies effectively is essential to building a national ecosystem of resilience. This is crucial for securing critical infrastructure, managing vital resources, facilitating rapid disaster recovery, enhancing interagency and public-private cooperation, and ensuring seamless information sharing [30].

The practice of digital sustainability will enhance people-centered governance, strengthen digital government functions, foster a culture of innovation, and complete the establishment of digital legal frameworks to bolster social trust. It also promotes broadband development in both urban and rural areas. For example, smart governments can implement comprehensive data management systems to protect citizens' personal information, making government services more accessible online. This will empower citizens to effectively engage with online services. Digital sustainability also promotes social inclusion, fosters an inclusive online community, strengthens democratic digital practices, and ensures equal opportunities for public digital development [31].

To achieve digital sustainability, enterprises should adopt the following strategies:

- 1) establish a robust digital governance system to safeguard digital human rights and promote digital trust, democracy, and stability. This includes the right to lifelong learning of digital skills, broadband access, personal data management, participation in online public affairs, and equal digital development opportunities;
- 2) foster innovation and embrace digital diversity as key drivers of sustainable development. This approach should reflect the diversity of national behaviors, cultural and environmental variations, and expand workforce participation to create an optimized economic structure;
- 3) strengthen national digital capabilities and connect diverse talent. This strategy involves raising digital literacy across the population, developing new digital talents, and leveraging the global digital elite. Human capital is foundational to sustainability;
- 4) enhance information security management and bolster national digital resilience. This involves creating a national ecosystem that is adaptable, integrating communication systems and human resources for effective national mobilization;
- 5) promote the integration of digital technologies and foster an inclusive digital economy and society. This includes advancing the digital and zero-carbon transformation in both public and private sectors, promoting smart and low-carbon operations, and ensuring digital innovations align with societal values of trust and democracy;

6) expand the digital frontier and uphold core values. The strategy should focus on "responsible manufacturing" by producing eco-friendly and secure digital solutions, positioning enterprises as global suppliers of sustainable digital technologies.

Developing strategies for digital sustainability within enterprises is critical. Green sustainable management encompasses the resilience to digital threats, safeguarding confidential information, and maintaining operational continuity, even during cyber-attacks or other disruptions [26].

**Key components of these development strategies include:**

- 1) conducting a comprehensive risk analysis to identify potential digital threats and vulnerabilities within the enterprise;
- 2) developing and implementing policies, procedures, and technological solutions to protect digital assets from potential threats;
- 3) ensuring that all employees are well-informed about digital threats, preventive measures, and incident response procedures for security breaches;
- 4) establishing and implementing data backup and recovery strategies to prevent the loss of critical information due to cyberattacks or unforeseen incidents;
- 5) adopting advanced technologies and protection methods, as well as continuously updating software and hardware to mitigate emerging digital threats;
- 6) performing regular security audits to identify vulnerabilities in information protection and ensure effective internal controls;
- 7) engaging security experts for consultations and developing more effective strategies to safeguard against digital threats [32].

Implementing these strategies will help enterprises maintain digital resilience and reduce the risk of data loss or security breaches, which could severely impact their operations. Digital technologies can play a pivotal role in achieving sustainable green development by accelerating innovation and minimizing negative environmental impacts. Below are some best practices in utilizing digital technologies for sustainable green development that have been successfully implemented internationally (**Table 3.2**).

These best practices demonstrate that digital technologies can serve as a powerful tool for achieving sustainable green development, accelerating the transition to environmentally friendly and sustainable economies. They not only help reduce negative environmental impacts but also contribute to economic growth and enhance competitiveness, making them key components in achieving sustainable green development.

The theoretical significance of the impact of digital technologies on sustainable green development lies in their potential to address complex environmental challenges, ensure the sustainability of natural resources, and reduce the negative effects of human activity on the environment [33].

**Table 3.2 Best practices for using digital technologies in sustainable green development**

No.	Best practices	Content and direction of sustainable green development
1	Intelligent energy networks	The introduction of digital monitoring and control systems in energy networks allows optimizing energy production and consumption, increasing efficiency and reducing harmful gas emissions
2	Smart agriculture	Use of data from sensors, drones and other digital technologies to optimize crop production, reduce the use of chemical fertilizers and resources, while conserving water and soil
3	Digital technologies in urban planning	The use of smart systems to control transport, lighting and water supply can reduce energy consumption and pollution, and improve the quality of life for city dwellers
4	Digital platforms for waste management	Developing digital systems that help track, manage and recycle waste more efficiently, promoting recycling and reducing emissions
5	Internet of Things (IoT) for sustainable production	The introduction of IoT sensors and communications in production processes can improve monitoring, planning and resource management, reducing costs and environmental impact
6	Using Artificial Intelligence (AI) for environmental monitoring	The use of AI to analyze large volumes of data allows for the timely detection of environmental problems and the development of effective strategies to solve them
7	Digital carbon credit markets	The emergence of digital platforms and blockchain technologies is enabling the creation of carbon credit markets where businesses can trade CO <sub>2</sub> emissions and incentivize environmental investments and emissions reductions
8	Digital solutions in water supply and water treatment	The use of digital technologies in water supply and water treatment enables efficient management and monitoring of treatment processes, reducing energy and chemical consumption, which helps to conserve water resources and reduce pollution
9	Digital solutions in forestry and logging control	The use of drones, satellite monitoring and artificial intelligence allows for effective monitoring and management of forest resources, preventing illegal logging and promoting sustainable forestry
10	The use of blockchain technologies in renewable energy	Blockchain can be used to track and certify renewable energy, ensuring transparency and integrity of data on its production and use
11	Electronic payment systems to encourage sustainable purchases	The introduction of electronic payment systems and loyalty programmes that provide discounts and bonuses for environmentally friendly goods and services can encourage consumers to consume sustainably
12	Digital technologies for climate change adaptation	The development and use of digital tools for predicting, monitoring and managing the effects of climate change helps to reduce its negative impact and increase resilience to its consequences

Source: compiled by the authors

Theoretical aspects include:

1. **Efficient resource utilization** – digital technologies enable the optimization of production processes and resource consumption, leading to reduced waste and pollution.

2. **Environmental monitoring and management** – through sensors, IoT, and data analytics, it is possible to effectively monitor the environment and respond to emerging negative trends.

3. **Promoting eco-friendly consumption** – digital solutions can raise consumer awareness of their environmental impact and encourage more environmentally conscious decision-making [34].

4. **Climate change forecasting and response** – the use of data analytics and artificial intelligence allows for more accurate climate change predictions and timely responses to their effects.

The synergy between digital technologies and green sustainable management strategies can be realized through several key principles:

- digital technologies enable the collection of large volumes of data on environmental indicators such as emissions, resource, and energy use, as well as the social impacts of businesses. Analyzing this data helps companies understand their environmental footprint and the social implications of their operations;

- the integration of technologies like the Internet of Things (IoT), artificial intelligence, and data analytics allows for the creation of "smart" management systems that optimize resource and energy usage, while minimizing waste and emissions;

- digital technologies facilitate efficient planning and resource management, reducing losses and optimizing resource usage, which aligns with the principles of green sustainable management;

- they also enable enterprises to ensure transparency and openness in their operations, including environmental and social performance, which enhances stakeholder engagement and trust in the business;

- stimulating innovation and green initiatives;

- digital technologies can drive innovation and the development of green solutions, supporting the implementation of green sustainable management strategies;

- digital tools can engage employees and stakeholders in the development and execution of green sustainable management strategies, fostering greater involvement and accountability.

Overall, the synergy between digital technologies and green sustainable management strategies allows businesses to more effectively implement green initiatives, reduce their environmental footprint, and contribute to sustainable development [35].

### 3.5 Conclusions

The theoretical significance of researching the synergy between digital technologies and green sustainable management strategies is determined by the following key aspects:

1. The research reveals the opportunities that digital technologies offer in green sustainable management. This includes identifying effective ways to leverage information technologies, the Internet of Things (IoT), data analytics, artificial intelligence, and other tools to optimize environmental efficiency and reduce negative impacts on the environment.

2. The study promotes the development of concepts and models that explain the mechanisms of interaction between digital technologies and green sustainable management. This could involve the creation of synergy theories, concepts of digital transformation in green business, and other related aspects.

3. The research defines key principles and strategies that help effectively integrate digital technologies with green sustainable management. This includes developing methodologies, guidelines, and recommendations for businesses and government organizations.

4. The study allows for the comparison and analysis of best practices in using digital technologies for green sustainable management. This helps identify successful strategies and methods that can be applied in various contexts.

5. The research fosters the development of new ideas and innovations in green sustainable management, including new approaches to solving environmental problems, developing new products and services, and building a sustainable economy.

The research on the synergy between digital technologies and green sustainable management strategies holds significant theoretical value as it contributes to advancing scientific knowledge and understanding the interconnectedness of these two areas of management.

The practical significance of the research includes real-world initiatives and projects that are already being implemented and showing successful results in achieving sustainable green development. The practical aspects of the impact of digital technologies on sustainable green development include:

1. Implementation of smart technologies in urban planning and transport: smart cities and smart transportation systems contribute to reducing emissions, improving energy efficiency, and enhancing the quality of life for residents.

2. Digital carbon credit markets and ecosystems: these platforms support the financing and promotion of projects aimed at reducing emissions and preserving the environment.

3. Smart agriculture and data-driven optimization: the use of advanced technologies in agriculture increases crop yields while reducing the negative impact on the environment.

4. Electronic waste management systems and resource recovery: digital solutions enable effective waste management and ensure the reuse or recycling of materials.

Theoretical knowledge about the potential of digital technologies for sustainable green development contributes to the development and implementation of practical initiatives that can genuinely improve the global environmental situation.

The synergy of digital technologies and green development plays a crucial role in achieving a sustainable environmental future, especially in the face of instability. Digital technologies such as artificial intelligence, the Internet of Things, and data analysis can be used to collect, analyze, and monitor environmental data, aiding in environmental management and problem detection. They also help optimize production processes and energy management, which can lead to a reduction in harmful emissions and resource consumption. For example, the use of "smart" energy management systems in construction can reduce electricity and water consumption.

Green development emphasizes an environmentally protective approach to development, considering the needs of modern society. This includes the use of renewable energy sources, reducing emissions into the atmosphere, and preserving natural resources. The synergy of these two directions lies in the fact that digital technologies can support the implementation of green initiatives. For instance, modern technologies in the transport sector can facilitate the introduction of electric vehicles and the development of charging infrastructure. Data analysis can help identify areas with the highest environmental stress and develop effective protection strategies.

In conditions of instability, such as climate change, economic instability, or crisis situations, the importance of this combination becomes even more evident. It enables more effective responses to challenges, ensuring a sustainable environmental future and reducing its vulnerability.

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