FORMATION OF A SUSTAINABLE ECONOMIC DEVELOPMENT MODEL BASED ON INNOVATIVE TECHNOLOGIES IN THE CONTEXT OF DIGITAL AND GREEN ECONOMY INTEGRATION

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Abstract: This scientific study analyzes the process of forming a new economic model — a sustainable, resource-efficient, and low-carbon economy — emerging as a result of the integration of the digital economy, the green economy, and innovative technologies. The impact of digital technologies on environmental efficiency, the modernization of production through innovative solutions, as well as the prospects of the "digital–green" transformation in Uzbekistan, are examined.

Keywords: digital economy, green economy, model, innovation, resource, digital–green, integration.

ФОРМИРОВАНИЕ МОДЕЛИ УСТОЙЧИВОГО ЭКОНОМИЧЕСКОГО РАЗВИТИЯ НА ОСНОВЕ ИННОВАЦИОННЫХ ТЕХНОЛОГИЙ В УСЛОВИЯХ ИНТЕГРАЦИИ ЦИФРОВОЙ И ЗЕЛЁНОЙ ЭКОНОМИКИ

Аннотация: В данном научном исследовании анализируется процесс формирования новой экономической модели — устойчивой, ресурсосберегающей и низкоуглеродной экономики, возникающей в результате интеграции цифровой экономики, зелёной экономики и инновационных технологий. Рассматривается влияние цифровых технологий на экологическую эффективность, модернизация производства с использованием инновационных решений, а также перспективы «цифрово-зелёной» трансформации в Узбекистане.

Ключевые слова: цифровая экономика, зелёная экономика, модель, инновация, ресурс, цифрово-зелёная, интеграция.

Introduction. In the last decade of the 21st century, two strategic economic models – the digital economy and the green economy – have emerged as the main directions of global economic development. As a result of their integration, a new economic paradigm is emerging – the "digital-green transformation".

Digital technologies (artificial intelligence, IoT, big data, blockchain) increase production efficiency, improve environmental monitoring, and ensure the rational use of natural resources. The green economy, on the other hand, combines economic growth with the principles of environmental sustainability.

This article scientifically substantiates the mechanisms for achieving sustainable economic development by combining these two areas with innovative technologies.

The digital economy is a system based on the use of digital technologies in economic processes, optimizing information flows, and improving management in real time.

Main components: Artificial Intelligence (AI), Internet of Things (IoT), Big Data, Cloud technologies, Digital platforms. The digital economy provides many benefits, such as automation of industrial processes, increased accuracy and efficiency in logistics systems, and reduced energy consumption.

focuses on energy efficiency, renewable energy sources, zero-waste technologies, and "smart" environmental management systems .

2348

Today, countries around the world are accelerating the transition to a green economy due to climate change and a sharp increase in carbon emissions.

This integration is called the "Green Digital Economy" and is manifested in the following areas:

"Smart energy" systems. Real-time monitoring of energy consumption using IoT and AI → optimization of power grids.

"Green logistics" . Optimization of road maps through digital platforms → reduction of fuel consumption and CO_2 emissions.

Digital waste management. Based on Big Data, the efficiency of waste sorting, recycling and planning will increase.

The role of innovative technologies in integration. Innovation is the main driving force of the digital and green economy.

Main innovation areas: Artificial intelligence-based environmental monitoring, Smart energy management sensors, Blockchain-based carbon footprint tracking systems, Robotics for green industry.

These technologies reduce production costs, increase energy efficiency, and minimize environmental pollution.

Researach discussion. In recent years, as a result of the aggravation of environmental problems on a global scale, the acceleration of climate change, the limitation of natural resources, the disruption of biosphere stability, and the negative anthropogenic impact of industrial production on the environment, new, sustainable and ecologically balanced development models of the economy are being introduced. As one of such conceptual approaches, the concept of green economy is attracting special scientific and practical attention.

The concept of a green economy aims to harmonize economic growth with the principles of sustainable development through environmental protection, rational and economical use of natural resources, waste minimization, carbon emissions reduction, and ecological footprint reduction. This approach has become a hot topic in both scientific circles and the global political agenda, driven by the increasing environmental risks and the need for adaptation strategies to climate change.

The theoretical foundations of the green economy are aimed at meeting human needs while preserving the resilience of ecological systems, transforming economic processes based on principles such as a careful attitude to nature, resource regeneration, eco-efficiency, and carbon neutrality. According to this model, economic growth, along with increasing human well-being, requires a responsible approach to the limited resources of nature.

Modern digital technologies are playing a crucial and accelerating role in these transformational processes. In particular, artificial intelligence (AI), Internet of Things (IoT), blockchain technologies, big data analytics, digital sensor systems, cyber-physical systems, automated monitoring platforms and other advanced technologies are widely used in the implementation of green initiatives.

With the help of these digital technologies: industrial processes are being optimized, energy efficiency is being increased, the integration of renewable energy sources is being strengthened, and the waste management system is being digitized.

However, along with the digitalization process, the innovative risks it can create are also increasing. In particular, the following: increased cybersecurity threats, disparities in technological adaptation and digital literacy, the risk of making decisions based on incorrect information (algorithmic bias), technological complications and information asymmetry, digital inequality, social imbalances and the digital divide can negatively affect the sustainability of the green economy.

Therefore, this scientific article deeply analyzes the opportunities for the development of a green economy using digital technologies, assesses technological and innovation risks in this process, and develops scientifically based mechanisms for their effective management. Through the research results, theoretical model, and practical recommendations, the conceptual framework for harmonizing digital transformation with the principles of sustainable development is developed, and the prospects of this direction in the conditions of Uzbekistan are scientifically substantiated.

Green economy and digital technologies are two intersecting, rapidly developing strategic directions, and the volume of scientific research on their mutual integration has increased significantly in recent years. International institutions, academic centers, and independent scholars have been promoting various conceptual and applied studies on this topic.

Globally, the UN, the World Bank, the International Energy Agency (IEA), and the Organization for Economic Cooperation and Development (OECD) have widely highlighted the importance of digital technologies within the framework of the green economy concept. For example, various UNEP reports recognize digital technologies as a key transformative factor in ensuring environmental sustainability.

Klaus Schwab's "The Fourth Industrial Revolution" provides an in-depth analysis of the impact of artificial intelligence, IoT, robotics, and other advanced technologies on the economy, including environmental sectors. The author argues that digital technologies expand the possibilities for efficient and economical use of resources.

Zhang and his colleagues have studied the role of IoT technologies in waste management, energy consumption control, and digital infrastructure in the concept of "green city". The researchers emphasize that digital systems are an integral part of environmental management mechanisms.

When it comes to innovative risks, Ulrich Beck's "Risk Society" theory is an important scientific source. According to Beck, with the acceleration of technological progress, new, difficult-to-predict risks arise, and modern strategies are needed to manage them.

In addition, Gartner experts in their analysis indicate issues related to cybersecurity, data integrity, technological adaptation and integration as key risk factors in the digital economy. They recommend developing mechanisms for early identification and effective management of these risks during the implementation of green technologies.

Preliminary scientific and practical research in this area is also being conducted in Uzbekistan. In particular, projects are being implemented by the Agency for Innovative Development under the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan, the Ministry of Economy and Finance, as well as organizations specializing in atmospheric monitoring, to collect, process and analyze environmental data using digital technologies.

This in research green economy and digital technologies integration related processes deep analysis to do, as well as innovative risks determination and them assessment for the purpose one row methodological from approaches used . Research works following main stages within step by step done increased :

First in stages green economy, digital transformation, innovation dangers and stable development concepts circle advanced foreign and local scientific sources, as well as UN Environment according to Programme (UNEP), Economic cooperation and progress Organization (OECD), World economic such as the World Economic Forum (WEF) international of institutions reports and analytical research deep studied. This in stages of the research theoretical-methodological foundation formed, the main of concepts content, their mutual dependency and scientific essence clarified .

Next in stages digital of technologies green in the economy place systematic approach based on research This was done . approach digital solutions, ecological environment, economic

efficiency and technological dangers between complicated mutual impact mechanisms determination opportunity gave.

This with together, Germany, South Korea and China such as digital transformation and green economy according to leader of countries experience studied, Uzbekistan to the conditions relatively comparative analysis done increased. In this digital of technologies green to the economy successful integration to be done for necessary was institutional and technological factors clearly was given.

The research important from directions one as digital of technologies green in the economy of use opportunities, advantages, weaknesses aspects, as well as to them typical was risks SWOT analysis using This was evaluated . analysis technological progress with related was social, economic and security factors between balance in determining important importance profession reached .

Final in stages all analysis results integration made and determined problems eliminate to grow and strategic decisions acceptance to do for practical recommendations working has been removed . Suggestions scientific based without working exit, Uzbekistan economy current development level and national to the conditions customized complex solutions in the form of formed .

Green economy and digital transformation today's global day in order one - one another with integral related   was   two strategic direction   as to the field is coming out . Their each other integration economic growth, ecological   stability and social PCB one of time in the room provide opportunity gives .

Green economy and digital transformation today's global day in order mutual integral related was two strategic direction as separated They are standing. integration not only economic growth processes encourages, but ecological stability strengthens and social justice and PCB provide opportunity creates . This research within held theoretical analysis, international experiments compare and expert requests as a result following main scientific analysis directions by designating received :

Modern digital of technologies green in the economy Application . Analyses this showed that the following advanced digital technologies green the economy formation and stable develop in the process main from tools one as service does :

IoT (Internet of Things) Things): Environment realistic time in mode monitoring to do, waste and water resources management, smart electricity networks through energy efficiency increase opportunity gives ;

Big Data and Artificial intelligence (AI): Ecological risks forecasting, natural from resources optimal use and green investments efficiency assessment opportunities creates ;

Blockchain Technology : Carbon loans observation, green of projects transparency provide and financial reliability in increasing effective tool as used ;

Digital Platforms : Green product and services promote to do, ecological education and consciousness development, as well as the population ecological in processes active participation encouragement opportunity gives .

This technological approaches all aspects digital solutions green of the economy main driver   as power) seeing to go out basis creates . This with together, they stability increase, resources efficiency provide and ecological strategies to practice current in doing important role plays .

Digitization in the process to the surface arrival possible was   The risks have also been identified, and the following main to categories separated :

Technological risks – technologies malfunction, system from work output, technical errors ;

Cybersecurity risks – environmental of information theft, forgery   information based on

wrong   decisions acceptance to be done ;

Information inequality – from technologies in use digital difference, especially village in the regions ;

Socio-psychological dangers - human resources and of experts readiness lack of technology of trust lowness ;

Research during respondents by exactly cybersecurity, data wrong   interpretation and technological inequality the most current dangers as was shown .

Table 1

Green economy used   digital technologies and their functions

Digital technology type	Usage field	Home functions	Ecological benefit
IoT (Internet) of Things)	Water, electricity and waste management	Real-time monitoring, automatic management	Resources saving, wastefulness reduce
Big Data & Artificial Intelligence	Environmental monitoring and forecast	Data analysis, risk prediction determination	In decision - making accuracy increases
Blockchain	Green finance, carbon loans	Transactions transparent observation	Corruption reduce, ecological projects i Reliable to do

Big Data and artificial intellect ecological risks in advance forecast to do and them reduce opportunity creates. Blockchain technologies through carbon loans such as green financial tools transparent and reliable is being managed . Digital platforms and population ecological literacy increase and them green in initiatives active participation to reach attraction in doing important role plays . This because of, digital technologies every one ecological activity in the field systematic application green economy strategy inseparable and main structural element is considered.

Table 2

Innovative danger - risks types

Danger type	Description	Solutions and management measure
Technological Malfunctions	Software and hardware errors, system from work output	Technical audits, backup systems create
Cybersecurity	Data theft, systems attacks	Cryptography, security protocols, staff readiness
Digital inequality	rural areas sufficient access to technology absence	Infrastructure development, digital literacy increase

E- waste (e-waste)	The environment of outdated equipment to the environment negative impact	Again work systems, ecological to standards compliance to do

Innovative dangers types and them management strategies" in the table analyses this shows that, digital technologies current to be with one in line new dangers also appearance is happening . Technological malfunctions, cyber threats and digital differences this the process Especially in cybersecurity   related problems ecological monitoring systems reliability serious threat gives birth. This because of risks management for complex strategies working exit must: technical audits, security protocols, qualified personnel preparation, re- work systems and infrastructure develop main measures as recommendation This is   risks in advance determination and effective management green of the economy stable in development important importance profession will reach.

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