

INDUSTRY 4.0: UZBEKISTAN'S PATH TO DIGITAL TRANSFORMATION**Mirziyodova Gulnoza Ayubkhan qizi****TSUE, scientific researcher****Annotation**

This article gives the concept of Industry 4.0, studies the experience of foreign leading countries in introducing modern digital technologies into the economy and industry, and evaluates their successes and problems along this path. The successes and problems of various sectors of the economy of Uzbekistan on the path of digital transformation, which lays the foundation for a modern and technological economy, i.e. on the path to transition to Industry 4.0.

Keywords: Industry 4.0, digitalization, robotic devices, big data, industrial Internet of things (IoT), 3D printing, blockchain, artificial intelligence, machine learning.

Аннотация

В данной статье дано понятие Индустрии 4.0, изучен опыт зарубежных стран-лидеров по внедрению современных цифровых технологий в экономику и промышленность, дана оценка их успехам и проблемам на этом пути. Также рассмотрены успехи и проблемы различных секторов экономики Узбекистана на пути цифровой трансформации, которая закладывает основу для современной и технологичной экономики, т.е. на пути перехода к Индустрии 4.0.

Ключевые слова: Индустрия 4.0, цифровизация, роботизированные устройства, большие данные, промышленный интернет вещей (IoT), 3D-печать, блокчейн, искусственный интеллект, машинное обучение.

Annotatsiya

Ushbu maqolada Sanoat 4.0. kontsepsiyasi berilgan, xorijiy etakchi davlatlarning iqtisodiyot va sanoatga zamonaviy raqamli texnologiyalarni joriy etish tajribasi o'rganilib, ularning bu yo'lda erishayotgan muvaffaqiyat va muammolariga baho berilgan. Zamonaviy va texnologik iqtisodiyotga poydevor qo'yuvchi raqamli transformatsiya yo'lida ya'ni Sanoat 4.0 ga o'tishsa, O'zbekiston iqtisodiyotining turli tarmoqlaridagi muvaffaqiyatlari va muammolari aniqlangan.

Kalit so'zlar: Sanoat 4.0, raqamlashtirish, robot qurilmalari, katta ma'lumotlar, sanoat narsalar Interneti (IoT), 3D bosib chiqarish, blokcheyn, sun'iy intellekt, mashinani o'rganish.

INTRODUCTION

In the heart of Central Asia lies Uzbekistan, a country with a rich history and vibrant culture. Traditionally known for its textiles, agriculture and natural resources, Uzbekistan is now setting its sights on a new frontier: Industry 4.0. While the world is undergoing a digital revolution, Uzbekistan is seizing the opportunity to embrace advanced technologies and enter the era of smart manufacturing and innovation.

Industry 4.0, often referred to as the fourth industrial revolution, is a paradigm shift in manufacturing and production processes driven by automation, data sharing

and artificial intelligence. It covers a wide range of technologies, including the Internet of Things (IoT), artificial intelligence (AI), robotics and advanced analytics, which are interconnected to create a holistic and efficient manufacturing ecosystem.

LITERATURE REVIEW

Different sources give different definitions of this term. For example, Professor Klaus Schwab in his book *The Fourth Industrial Revolution* describes Industry 4.0 as “new technologies that connect the physical, digital and biological worlds, touching all disciplines, economies and industries. These technologies have enormous potential to connect billions of people online” and significantly improve the efficiency of businesses and organizations.” [1]

Some commentator promotes a similar idea under the name of cyber physical systems, smart factory, smart production, machine-to-machine, advanced manufacturing, internet of things, internet of everything or industrial internet [2]. Industry 4.0 or fourth industrial revolution also refers to the next phase in a digitization of the manufacturing sector where the Internet of Things (IoT) looks to play a huge role that have the potential to feed information into it and add value to manufacturing industry to realize a low-volume, high-mix production in a cost-efficient way [3] Industry 4.0 comprises a paradigm shift from automated manufacturing toward an intelligent manufacturing concept. The physical and virtual worlds grow together and objects including machines are equipped with sensors and actuators [4]. Intelligent manufacturing implementation will make use of concepts such as IoT to facilitate this change. The exclusive feature in I4.0 is to fulfill individual customer requirements with product variants in a very small lot size, down to one-off items [5].

RESEARCH METHODS

In the article, the main research methods are: collection of information on the research topic from books, scientific articles and Internet sources; theoretical and statistical analysis, as well as interpretation of the information received; establishing the causes and summarizing the revealed facts; study of methods and tools for effective promotion of goods using digital technologies

For the further development of this area in our country, this article studied the experience of foreign leading countries in introducing modern digital technologies into the economy and industry, and also assessed their successes and problems along this path.

ANALYSIS AND RESULTS

Starting our research with Germany, the country where this concept originated in 2011, as a project aimed at increasing the competitiveness of the manufacturing industry . Germany is often called a leader in Industry 4.0. Here, industrial companies are actively implementing automation systems, the Internet of Things (IoT), data analysis and robotic systems. Production processes are becoming more flexible and efficient, allowing German companies to remain competitive in the global market. The German government, together with Bosch and Siemens, is implementing the Industry

4.0 program and a new service-oriented business model. The Industry 4.0 concept is based on the concept of the Internet of Things (and Services), which assumes that every machine, part or finished product is equipped with built-in digital technologies that allow them to interact with other objects and with people. Germany's plans to internetize industry by 2030. According to Eberhard Veit, head of the Industry 4.0 platform, Germany has already invested 10 billion euros in the development of a new production base, while only about 1 billion euros have been allocated for training in this area [6].

Another European country where the digital industry is thriving is the UK. In 2017, this country presented its own Digital Strategy - the document includes seven areas in which the country intends to develop the "leading digital economy" in the world. In particular: creating a world-class digital infrastructure in the UK; giving everyone access to essential digital skills; creating conditions in the country as the best place to start and develop a digital business; helping every UK business go digital. There are plans to invest £17.3 million into university research into robotics and artificial intelligence. Consultancy Accenture estimates that the use of artificial intelligence will bring an additional £654 billion to the UK economy by 2035.[7]

The next leader is the United States, where companies are actively implementing Industry 4.0 technologies, especially in the automotive, electronics and high-tech industries. California, for example, is a hub for the development of artificial intelligence and autonomous vehicles. However, unlike other changes, the United States has different regional approaches to Industry 4.0 and uneven technologies.

Undoubtedly, China, an Asian country occupying a leading position in the global economy, is actively investing in the development of Industry 4.0, striving for technological leadership. Chinese companies are introducing automation and robotization systems on production lines, and are also developing their own technologies in the field of artificial intelligence and the Internet. Government support and access to a huge foreign market create favorable conditions for the development of innovation. According to Zhang Xinhong's article in "With zinczi Zhibao," the development of the digital economy in China is logically predetermined by three main points [8].

1. Creation of high-speed and universal infrastructure. The largest broadband network has been built. Internet penetration rate is more than 50%.
2. Penetration of the digital economy into all spheres of life and production.
3. The constant emergence of new business status and new models.

Japan is also playing an important role in the development of Industry 4.0, with a particular focus on robotics and industrial automation. Japanese companies are actively introducing robots and automated systems in various industries: from automotive to electronics and medicine. However, Japan also faces challenges such as an aging population and the need to update infrastructure to support new technologies.

One of the "Asian Tigers" - South Korea is one of the leaders in digital transformation. Korean companies are actively implementing the Internet of Things, artificial intelligence and robotic systems, especially in the semiconductor, automotive

and electronics sectors. Government support and a high level of digital literacy of the population contribute to the successful development of Industry 4.0 in South Korea.

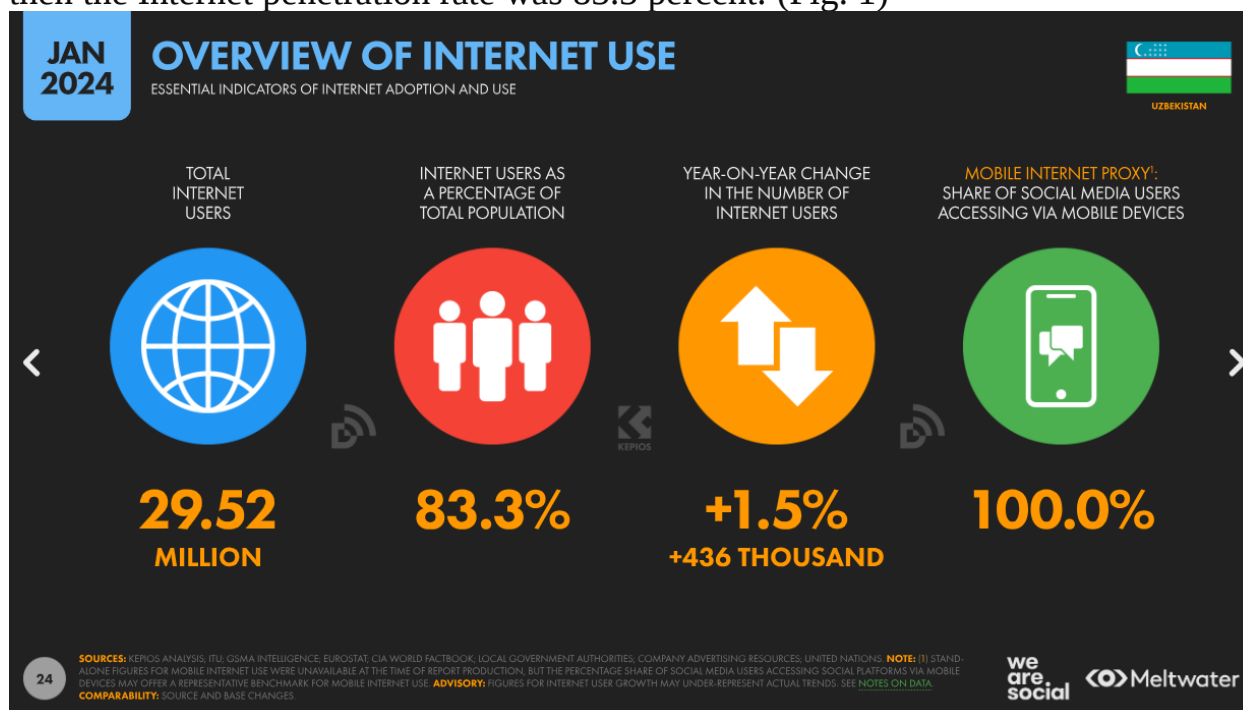
At the same time, Uzbekistan, one of the developing countries, due to its strategic location at the crossroads of Asia, has realized the importance of introducing Industry 4.0 technologies in order to remain competitive in the global market. With a population of over 37 million, Uzbekistan provides unique opportunities for businesses looking to expand into new markets. Under the leadership of President Shavkat Mirziyoyev, the country has embarked on an ambitious journey of digital transformation, laying the foundation for a modern and technologically advanced economy.

One of the key initiatives underlying the implementation of the Industry 4.0 program in Uzbekistan is the Digital Uzbekistan 2030 program, the goal of which is to use the capabilities of digital technologies to accelerate economic growth and improve the quality of life of citizens. The program aims to expand broadband infrastructure, improve digital literacy and promote innovation and entrepreneurship in key sectors such as manufacturing, agriculture and healthcare.[9]

It is important to note that the Republic is implementing comprehensive measures for the active development of the digital economy, as well as the widespread introduction of modern information and communication technologies in all industries and areas, primarily in public administration, education, healthcare and agriculture.

According to company reports “We are social” and “Meltware” you can see the following data on the implementation and use of digital technologies in Uzbekistan at the beginning of 2024 :

- At the beginning of 2024, there were 29.52 million Internet users in Uzbekistan, then the Internet penetration rate was 83.3 percent. (Fig. 1)

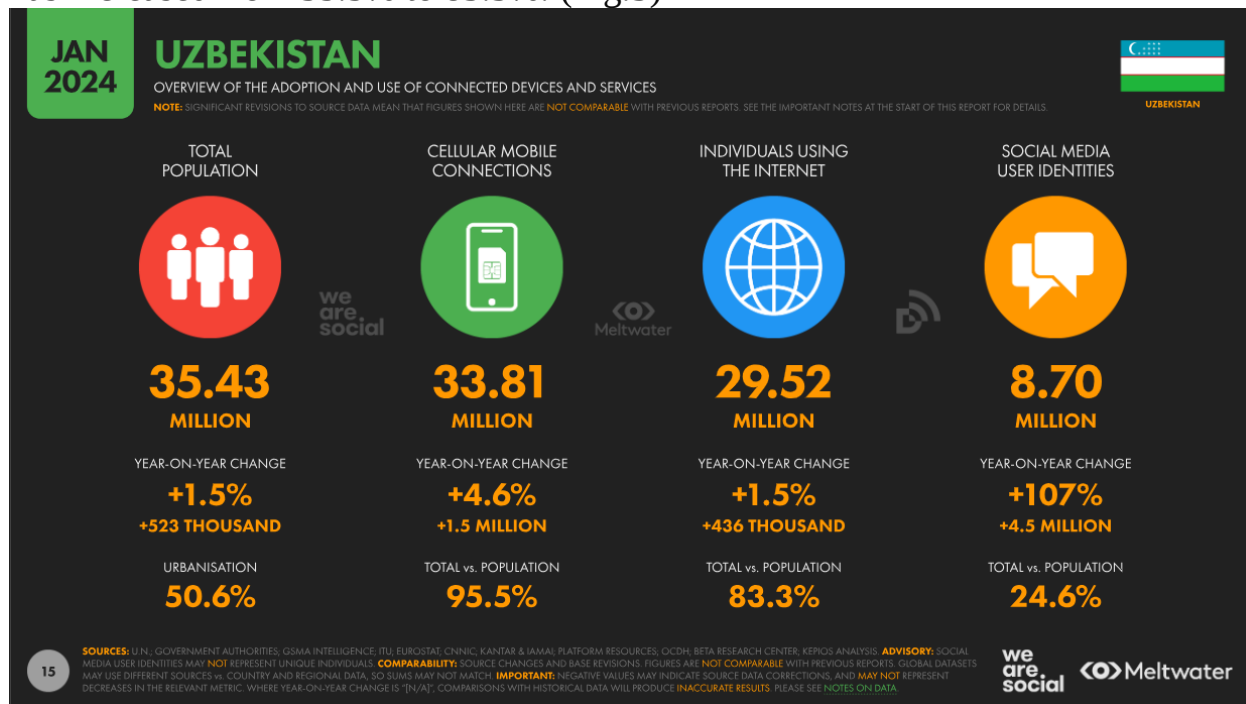


Pic.1. Number of Internet users at the beginning of 2024 in the Republic of Uzbekistan[10]

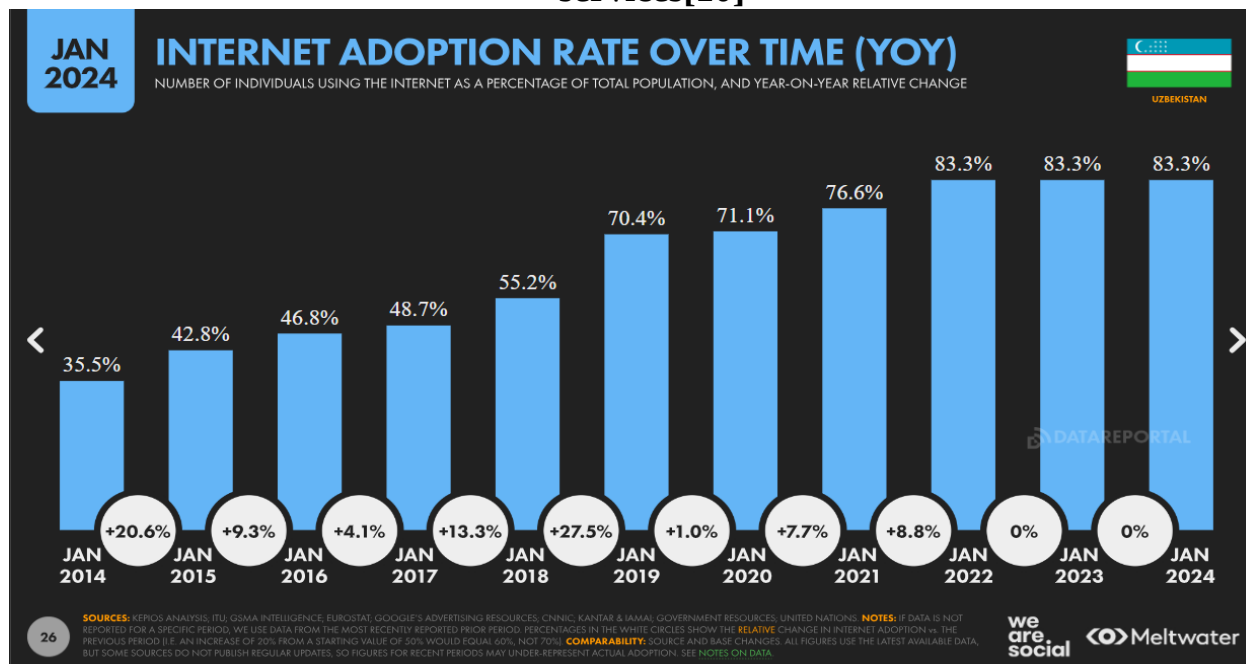
-In January 2024, there were 8.70 million social media users in Uzbekistan, accounting for 24.6 percent of the total population.

-In total, at the beginning of 2024, there were 33.81 million cellular mobile connections in Uzbekistan, which is equivalent to 95.5 percent of the total population (Fig. 2)

It is also important to note that over the past 10 ears, the Internet penetration rate has increased from 35.5% to 83.3%. (Fig.3)



Pic . 2. Overview of the adoption and use of connected devices and services[10]



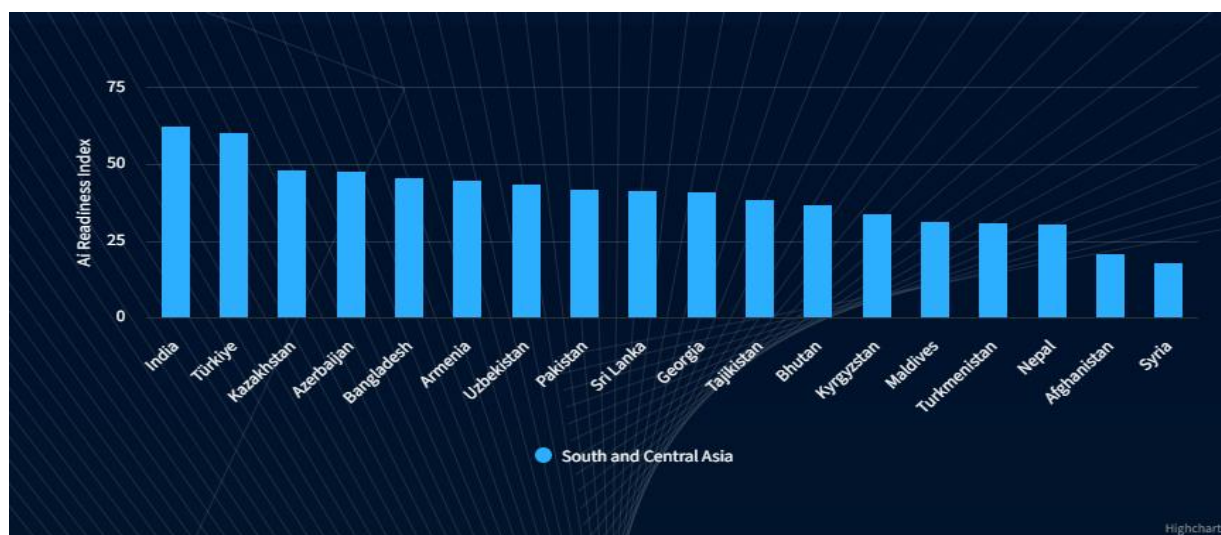
Pic.3. Internet penetration level over the past 10 ears (2014-2024) in the Republic of Uzbekistan [10]

In particular, the implementation of more than 220 priority projects has begun, providing for the improvement of the e-government system, the further development of the domestic market for software products and information technologies, the organization of IT parks in all regions of the republic and the provision of qualified personnel in this area. In addition, a comprehensive program “Digital Tashkent” is being implemented, which provides for the launch of a geoportal integrated with more than 40 information systems, the creation of an information system for managing public transport and municipal infrastructure, digitalization of the social sphere with the subsequent dissemination of this experience to other regions.[9]

The country’s next important victory is its rise over the past 5 ears from 158th place to 87th in the world (Fig. 4) and 7th place among the countries of South and Central Asia in the Government rating Artificial Intelligence Readines Index ", developed by the British organization Oxford Insights . (Fig. 5)



Pic.4 . Indicators Republic Uzbekistan V international rating "Government Artificial Intelligence Readines Index" [11]



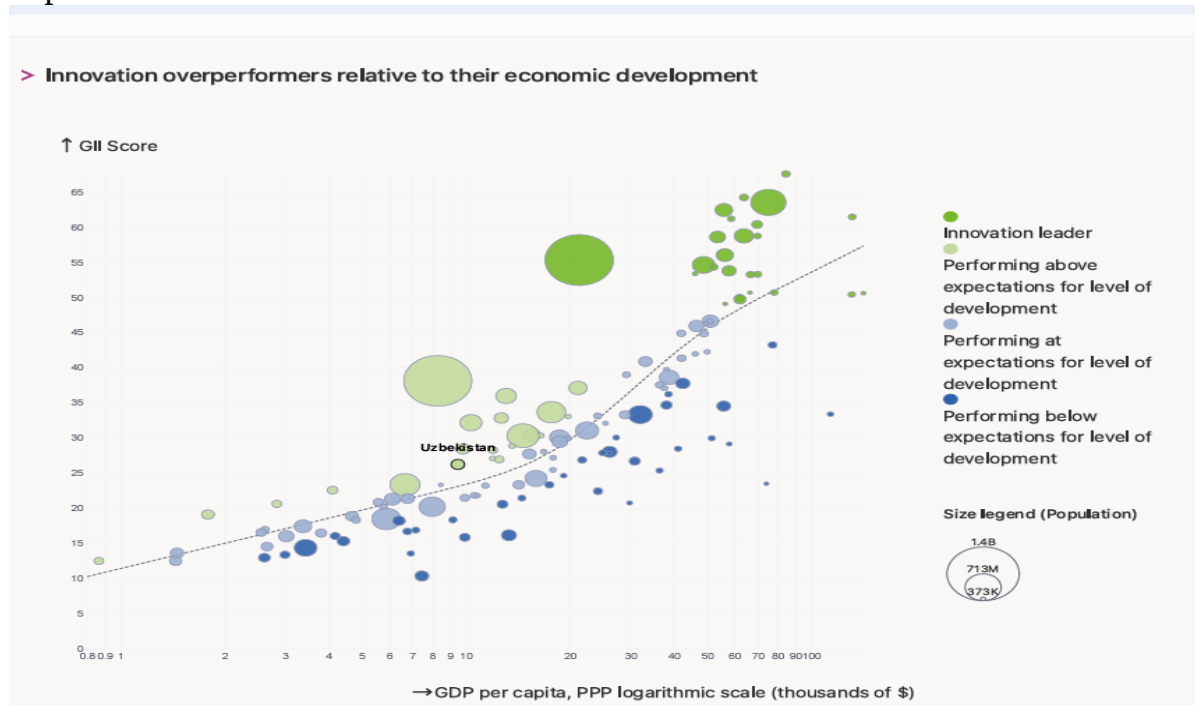
Pic.5. Indicators of the Republic of Uzbekistan in the international rating “Government Artificial Intelligence Readines Index” among the countries of South and Central Asia [11]

The next rating, where Uzbekistan has improved its position by 11 units over the past 4 years, rising from 93 to 82 place - “The Global Innovation Index (GII)” (Fig. 6). Also, it is important to note that today the economy of the Republic in this index ranks 4th among 10 economies of Central and South Asia.

	GII Position	Innovation Inputs	Innovation Outputs
2020	93rd	81st	118th
2021	86th	75th	100th
2022	82nd	68th	91st
2023	82nd	72nd	88th

Pic.6. Indicators of the Republic of Uzbekistan in the international rating “The Global Innovation Index (GII)” [12]

The picture below (Figure 7) shows the relationship between income levels (GDP per capita) and innovation performance (GII indicator). The trend line shows the expected efficiency of innovation depending on income level. Economies above the trend line perform better than expected, while countries below perform below expectations.



Pic.7. Relationship between income levels (GDP per capita) and innovation performance (GII indicator) [12]

In this chart, we can clearly see that the Republic of Uzbekistan shows excellent results, and is one of the countries where, compared to income level, the efficiency of innovation exceeded expectations.

It is interesting to note that on October 24-27, 2022, as part of the main event of the year in the field of information technology “ICTWEEK UZBEKISTAN 2022” held in Samarkand, the first results of the joint initiative “DIGITAL PULSE”, implemented by the Ministry of Economic Development and Poverty Reduction of the Republic of Uzbekistan, were presented and the United Nations Development Program, in partnership with the Ministry for Development of Information Technologies and Communications of the Republic of Uzbekistan and IT Park.

This tool has already helped diagnose the level of digitalization of business processes in more than 250 companies; the diagnostic results formed the basis for individual digital transformation strategies for small businesses, identifying the strengths and weaknesses of the enterprise, as well as the potential for further development.

DIGITAL PULSE is a tool that helps small and medium-sized businesses determine their level of digitalization and provides key recommendations on what to do on their digital transformation journey. The tool also helps companies assess their digital potential and identify associated gaps in their operations, and informs UNDP and its institutional partners on what further policy interventions need to be developed to support the acceleration of digital economy activities in the country.

This tool meets business needs for a free assessment and automatic analysis received by the company after undergoing diagnostics, and also provides basic recommendations on areas requiring improvement. The tool is useful for any company, large or small, service or product oriented [13]

In the manufacturing sector, Uzbekistan is investing heavily in smart factories and automation technologies to increase productivity, reduce costs and improve quality control. Using IoT sensors and connected devices, manufacturers can monitor equipment performance in real time, predict maintenance problems, and optimize production processes for maximum efficiency.

In addition, the digitalization of industry is evidenced by the use of new types of equipment, which include:

- robotic devices, waste-free and manless technologies,
- flexible technological systems, automatic production systems, unmanned
- transport, automated technical and technological platforms
- various stages of the production process, equipped with digital
- sensors, detectors, etc. [10]

Digital solutions are penetrating deeper into the business processes of oil and gas companies; the industry is actively cooperating with IT companies and creating its own centers of competence in this direction. This process is a consequence of the new technological revolution, the so-called “Industry 4.0”, a direct part of which is the digitalization of industry. In oil production, it involves the development and implementation of solutions in the following key technological areas:

- Big data (BigData, including artificial intelligence and machine learning) are tools and methods for organizing, storing, processing, working and performing calculations with huge amounts of data.
- The Industrial Internet of Things (IoT) is a system of unified computer networks and connected physical objects (things) with built-in sensors and software for collecting and exchanging data, with the possibility of remote monitoring and management in an automated mode.
- Robots and drones that help automate processes, perform hazardous work, and conduct visual or “tactile” exploration of hard-to-reach objects, such as subsea mining equipment.
- Digital twins are a model of a field, well, equipment or infrastructure elements that allows you to test and predict the effects of using certain options/solutions, as well as visualize the results obtained in a user-friendly form. Often combined with augmented reality tools.
- Smart materials are a class of materials with different physical states that retain or acquire specified physical and chemical characteristics when external conditions change, even to extreme ones.
- 3D printing used in mining for prototyping development projects and field development schemes, as well as for creating new components for sensors and controllers, pumps and other oversized equipment.
- A distributed ledger (blockchain) is a decentralized public application that allows record keeping and provides a high level of system security.[14]

Also, active digitalization is taking place in the mining and metallurgical sector of the Republic. For example, Almalyk MMC JSC, the leader in gold mining in Uzbekistan and the largest copper producer in Central Asia. developed a five-year digital transformation roadmap. Implementing several dozen projects annually, the company gradually automates technological and management processes. By 2023, data on mineral resources will be digitized, electronic document management and electronic journals will be introduced, and BI dashboards of key business processes will be created.

Additionally, the introduction of artificial intelligence and machine learning algorithms is revolutionizing traditional manufacturing practices by enabling predictive maintenance, demand forecasting, and adaptive manufacturing processes. This not only improves operational efficiency, but also allows manufacturers to quickly respond to changing market demands and customer preferences.

Besides manufacturing, Uzbekistan is also exploring the potential of Industry 4.0 in other key sectors such as agriculture, transport and healthcare. For example, in agriculture, IoT-enabled sensors and drones are used to monitor soil moisture levels, optimize irrigation, and improve crop yields. In transportation, intelligent logistics solutions optimize supply chain operations, reduce delivery times and reduce costs.

Moreover, the introduction of telemedicine and digital health platforms improves access to healthcare services in remote areas, provides patients with tools for self-monitoring and early intervention, and improves the overall quality of healthcare.

CONCLUSION

In conclusion,, although Uzbekistan has made significant progress in implementing Industry 4.0, challenges remain. Infrastructure limitations, including insufficient internet connectivity and digital skills gaps, pose barriers to widespread adoption. Additionally, data privacy and cybersecurity issues need to be addressed to ensure the integrity and security of digital systems.

However, with a clear vision, strong leadership and strategic investment, Uzbekistan is well positioned to capitalize on the opportunities presented by Industry 4.0 and become a leader in the digital economy. By promoting collaboration between government, industry and academia, Uzbekistan can unlock the full potential of digital technologies to drive sustainable growth, create jobs and improve the living standards of its citizens.

However,

Industry 4.0 represents a transformative opportunity for Uzbekistan to leapfrog into the digital age and position itself as a regional hub for innovation and technology-enabled development. By embracing cutting-edge technology and a culture of innovation and entrepreneurship, Uzbekistan can chart a course towards a prosperous and sustainable future in the Fourth Industrial Revolution.

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