Intelligent specialization as a promising strategy for the sustainable development of industrial regions of Ukraine (the case of Kryvyi Rih industrial region)

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Abstract. The paper discusses the basic principles of sustainable development as the dominant strategy for economic development, showcasing the features of its introduction in the major industrial regions of Ukraine. Substantiates the belief that the impact greening production useful in industrial regions, particularly in Kryvyi Rih, introduce European, including Polish experience intelligent (reasonable) specialization that takes into account the specificity of resources of the region and is based on the introduction of the latest smart technologies.

1 Introduction

The socio-economic situation in Ukraine is characterized by a complicated environmental legacy and hostilities in the East (2014-2020), which significantly hamper the country's sustainable economic development. Increasing concentrations of harmful substances in the atmosphere, destruction of forests, the disappearance of many species of fauna and flora, disturbance of ecosystems accompany the technogenic activity of the Ukrainian industrial complex and hostilities in the Donetsk industrial region. Moreover, the technological equipment of the country's great industrial enterprises is out of date, which does not meet the European environmental safety standards. This is especially true for large industrial regions, one of which is the Kryvyi Rih Iron and Metallurgical Region, one of the most powerful in Europe, producing about 80% of iron ore and 20% of metal, but with gross emissions of significant pollutants (dust, oxides) Kryvyi Rih is one of the first in Ukraine [1]. As Y. Maiakov, expert in geological and environmental studies GS "Environmental Council Kryvorizhzhya" said, Krivyi Rih and the entire region are under excessive environmental impact due to the multifaceted industrial areas that have a significant negative impact on the natural environment and pollute atmospheric air, groundwater, surface water, and soil. It results in human-made changes to natural landscapes, increasing the dose load on the population Rodney radionuclides, deteriorating health, and social indices [2].

An extremely critical ecological and economic situation in the Donetsk industrial region occurs, where Russian aggression has led to the loss of 50% of its industrial potential. Equipment for individual companies was exported to the territory of the Russian Federation or dismantled for scrap [3].

Therefore, it is worth acknowledging that the sustainable development goals, which have been recognized as strategic in the country for the last twenty years, have not been practically achieved, and that is why the Ukrainian society as a whole and the regional communities, in particular, have an urgent need to optimize their livelihoods, mainly production and consumption. That is why the problem of search and scientific substantiation of the newest concepts of economic development and ecological safety in the industrial regions of Ukraine, which can "breathe" into the strategy of sustainable development a new perspective idea, is actual.

The Sustainable Development Concept is a modern global trend for the last fifty years, it "aims at changing human-nature relationships to enhance economic growth and to create a coordinated global human survival strategy focused on conserving and restoring natural resources on a scale needed to bring communities back to scale of limits of economic capacity of the biosphere" [4].

Scientific research in the field of sustainable development is being carried out not only by economists but also by ecologists, political scientists, and sociologists since its implementation is connected with the most important spheres of human life – natural and social. Scientists considered ways and tools of transition to sustainable development, identified its indicators, formulated mechanisms of introduction of energy-saving and ecological safety systems, substantiated the levels of environmental impact on industrial enterprises on the environment.

The regional aspect of sustainable development is also reflected in the theoretical, methodological, legal, and scientific-methodological developments regarding its formation and implementation in the system of state and regional government through scientific research in this direction. Odesa, Kyiv, Dnipro, Lviv and Donetsk scientific schools represented them in the regions of Ukraine, but not so long ago noted by Ukrainian

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researchers, "scientific achievements have not been translated into administrative decisions at the state or regional levels. The results of scientific studies remain unused by management for the potential for sustainable development in the regions of Ukraine" [5].

Meanwhile, the modern period of economic development in European countries is focused on the search and implementation of new strategies, one of which is smart development, dominated by the union of science and business, the introduction of smart technologies, and intelligent (smart) specialization.

Therefore, *the purpose of this paper* is to analyze the features of the implementation of the sustainable development strategy in the industrial regions of Ukraine, in particular in the Kryvyi Rih industrial region and to substantiate the prospects and opportunities for the introduction of new strategies, namely smart specialization as a modern dominant of sustainable development.

2 Sustainable development as a world doctrine: the Ukrainian context

The issue of sustainability is one of the most studied not only in economics and ecology but also in environmental sociology, geography, and even ethics and culture. It is because the concept of sustainable or balanced development applies not only to environmental and economic aspects of economic development but also to virtually all other spheres of human life: social, cultural, domestic, medical, and other. It requires not only technological change in production technologies but also in value reorientations in the minds of the population, especially young people and those engaged in entrepreneurial activity or working in state structures. It is no coincidence that the Sustainable Development Challenge embraces at least two major ideas:

first, this development involves addressing economic, social, and environmental problems, namely "achieving a balance between the various factors that determine the overall standard of living"; and, secondly, "the present generation has a duty to the future generations to leave sufficient reserves of social, natural, and economic resources to enable them to secure a level of well-being no lower than what we have now" [6].

The term "sustainable development" was first formulated by prime minister of Norway Gro Harlem Brundtland, in a report entitled "Our Common Future", prepared for the United Nations and published by the International Commission on Environment and Development in 1987, defined it as "a development that meets the needs of today, but does not compromise the ability of future generations to meet their own needs" [7].

This definition clearly expressed concern for the future generation, which may inherit polluted air, depleted natural resources, and deforested landscapes as a result of the generation of the present. Moreover, Brundtland has compelled humanity not only to pay attention to its concern for the environment but also to listen to its message, which called for everyday ways to conserve the environment through balanced, rather than accelerated and destructive use by environmental entities. The answer to her message was the concept of sustainable (balanced, sustainable, eco-development) development.

The analytical work carried out by Ukrainian experts with the support of the United Nations Development Program in Ukraine and the Global Environment Facility in the framework of the project "Integration of Rio provisions into national policy of Ukraine" resulted in the development of the Sustainable Development Strategy of Ukraine until 2030 and the National Action Plan until 2020, which aims to Ukraine's fulfillment of international obligations and creation of real preconditions for Ukraine's full membership in the European Union, including the implementation of the EU-Ukraine Association Agreement [8].

An essential role in the implementation of the principles of sustainable development in Ukraine was also played by the National report "Socio-economic potential of sustainable development of Ukraine and its regions", which reveals the methodology of forming a system of indicators of the development of regional socio-economic systems as a fundamental prerequisite for sustainable development of Ukraine and the system of criteria for assessing its social and economic potential [9]. The preparation and publication of this document provided an impetus for the release of the Decree of the President of Ukraine "On the Strategy of Sustainable Development of Ukraine until 2020" January 12, 2015 № 5/2015 [10].

Ukrainian economist B. M. Danylyshyn defines sustainable development as "a system of relations of social production, which achieves the optimal balance between economic growth, the normalization of the quality of the natural environment, the growth of material and spiritual needs of the population" [11].

Therefore, to ensure balanced development is not a purely technical problem that requires new technical means or technologies. It is a problem of changing the format and nature of social relations, the reorientation of social and individual consciousness to reasonable needs, to a careful attitude to nature, to environments, and its existence. That is balanced development – a claim behind this development model, which also has an ethical sense, this "shift in value orientations of many people" [12]. This is a comprehensive development strategy for the near-century.

It is no coincidence that on September 15, 2017, the Government of Ukraine presented the National Sustainable Development Goals: Ukraine report, which presents the results of the adaptation of 17 global basic sustainable development goals, taking into account the specifics of national development in four areas: fair social development; sustainable economic growth and employment; effective management; ecological balance and sustainability building [13]. According to this Program, Ukraine's public vision for 2030 encompasses such benchmarks as: improving the well-being and health of the population through innovative development of an economy based on sustainable use of natural resources; changes in the structure of exports that shift from raw materials and primary processing products to high value added products and services; economic growth on the green economy model; reduction of energy intensity of

gross domestic product due to energy saving measures and implementation of energy efficient practices; a steady increase in the share of green energy production, displacing, above all, traditional technologies, which will significantly reduce greenhouse gas emissions into the atmosphere [13]. These benchmarks should be considered simultaneously as indicators of the implementation of a sustainable development strategy.

Of course, the achievement of these sustainable development goals in Ukraine should contribute to improving the quality of life of the population without harming the environment and increasing life expectancy. However, the environmental situation in modern Ukraine is hugely complex, which significantly hinders the implementation of these ideas. Eight years ago, the head of the Ukrainian Ecological League, T. Tymoczko, noted that there are at least eight acute environmental problems in Ukraine that make it impossible for a stable and optimized development of the country, namely: poor quality water (80% of water samples show that its quality does not meet the requirements of the state standards); polluted air (more than 6 million tons of pollutants and carbon dioxide are released into the atmosphere annually); degradation of land resources (more than 35% of agricultural land has undergone erosion; 2.4 million hectares of acid soils have increased over the last 15 years due to fertilizers; nearly 40% of Ukraine's total land resources belong to contaminated lands); forest destruction (timber exports from Ukraine are 2.5 times higher than imports; the area of forests affected by pests and diseases is continually increasing); dangerous geological processes (41-43% of the country's GDP related to the extraction and processing of mineral resources concentrated in the mining regions of Donbass, Kryvbas, Carpathian region, the ecology of these regions suffers not so much from intensive extraction, unprofitable and produced mines and quarries); municipal waste (there are about 800 official landfills in the country, with a total amount of waste in excess of 35 billion tons); objects of military activity, of which 90% are morally and physically obsolete and operate with significant congestion); Chornobyl disaster (total activity of radionuclides beyond the 4 Chornobyl NPP units on April 26, 1986 and in the days following the accident, exceeded 300 million Curie, leading to radioactive contamination of more than 145 thousand square kilometers in Ukraine, Belarus and Russia) [14].

Is there any reason to argue that the concept of sustainable development has recently become actively implemented in large industrial regions of Ukraine? Are there any positive results? What are the blockers for this process?

3 Realization of the Sustainable Development Goals in the Industrial Regions of Ukraine

Today's economy of Ukraine can be attributed mainly to raw materials, where the most developed are iron ore and metallurgical industries. The main areas of the coal, iron ore, and metallurgical industries in Ukraine are the Donetsk, Dnipro, and Azov regions. The largest producer of steel and rolled products is Dnieper Metallurgical Region, formed based on its own iron ore (Kryvyi Rih, Kremenchuk, Kerch, Belozerskoe deposits), manganese ore (Nikopol and Velykotokmatske) flux and limestone, and which produces 95% iron and 100% manganese ore, about 50% iron, steel and rolled metal, as well as 66% steel pipes and 83% ferroalloys [15].

The core of the Dnieper Metallurgical Region is the mining and metallurgical complex of Kryvorizhzhya (one of the primary budgetary formers of Ukraine, which includes: "ArcelorMittal Kryvyi Rih" – the largest enterprise of the mining and metallurgical complex of Ukraine with a full-cast iron mill, enterprises of underground mining of iron ore, coke-chemical production. The activity of ArcelorMittal Kryvyi Rih is supported by numerous mining equipment factories and regional industrial enterprises and research institutions. The differentiators of the complex include: mass scaling, enterprise occupies large areas, extraction of minerals from the depth, terrific environmental concerns, pressure on the environment [16].

As noted by H. H. Gubin and G. V. Gubin, as a result of mining and processing activities in Kryvbas, became "large-scale disturbance of the earth's crust and development of technogenic exogenous processes such as landslides, dips, subsidence of soil, disturbance of the foundations of buildings, as well as geotectonic processes – movement of blocks the crust in the horizontal direction 3-10 mm/year, which are fixed, in the vertical direction – 2-5 mm/year" [17]. Besides, industrial production leads to the pollution of land, water, and air basins with toxic metals of anthropogenic origin, the most dangerous of which are iron, chromium, zinc, mercury, lead, cadmium, and others. These metals, accumulating in soils in too large volumes, contaminate them and lead to chemical changes, which harms human health, reducing their natural immunity, and therefore the average life expectancy [18]. It means that in the ecological environment of industrial regions irreversible processes occur, which disturb the natural and social equilibrium, and gradually lead to the destruction of the ecosystem and the Earth's crust, and also lead to socio-demographic changes in the social structure of the regional society.

Following the goals that are correlated with the goals of the sustainable world development, which were approved at the UN Summit in 2015, the management of modern Ukrainian enterprises, in particular, Kryvyi Rih, was forced to adjust their activities to technological, environmental, and social changes, which met the set goals. However, often these are just imitations of change since behind the scenes of minor technological improvements are often at the heart of the activities of industrial enterprises outdated technology or equipment.

Undoubtedly, one of the leading indicators of its implementation is the ecological status, since it is, on the one hand, the result of industrial activity, and on the other - the cause of the health and morbidity of urban residents, which also testifies to the results of the implementation of environmental protection programs.

According to the State Statistics Service, the environmental situation in Ukraine remains rather

complicated. Thus, emissions of pollutants and greenhouse gases into atmospheric air from stationary sources of pollution in 2018 amounted to 2508, 3 thousand tons [19]. It means that each resident of Ukraine in 2017-2018 had about 60.8 kg of pollutant emissions. In terms of territorial area, there are about 4.5 tons of air pollutants per square kilometer of the country's territory. It is in Donetsk and Dnipropetrovsk regions that these figures have significantly exceeded the national average. Thus, in the Donetsk region, emissions per one square kilometer were 6.6 times higher, and for one person three times higher, in Dnipropetrovsk region (in particular the city of Kryvyi Rih) – 4.6 and 3.3 times respectively [20].

According to the information of industrial enterprises, emissions of pollutants into the atmospheric air of the city of Kryvyi Rih do not decrease, but on the contrary – increase. Thus, for the nine months of 2019, they amounted to more than 210 thousand tons, which is 10% more than in the same period last year, and the volume of industrial waste generation – 178.2 million tons, which compared to the same period of 2018 increased by 3.7%. The primary air pollutants are the enterprises of PJSC "Arcelor Mittal Kryviy Rih", LLC "Metinvest-KRMZ" and PJSC "INGZK" [21].

How catastrophic is characterized by experts in the ecological and economic situation in the Donetsk region? By the beginning of the military conflict, there were 4 240 potentially dangerous sites in the Donbas, and by the end of 2018, 176 had been identified, 99 of which were located in uncontrolled territory, 36 mines flooded and were not recoverable; uncontrolled air pollution, use of powerful ammunition, disturbance of terrain and soil cover, chemical contamination of soil with heavy metals, petroleum products and other toxic substances leading to the destruction of entire natural ecosystems are a serious danger [22].

As a result of the military conflict in the Donbas, ecosystems in at least 530 thousand hectares have been destroyed, including in 18 nature reserves with a total area of 80 thousand hectares. Also, 150,000 hectares of forest were affected by numerous fires in the area adjacent to the war zone [23].

As a positive result, it should be noted that in Kryvyi Rih region operates urban programs to address the environmental problems of Kryvbas and the improvement of the environment for 2016-2025. The program aims to focus on actions of state authorities, local self-government and their executive bodies, organizations, institutions, and enterprises of the city of all forms of ownership for the implementation of priority areas of activity in the field of effective environmental management, compliance with environmental safety and environmental protection, educational activities and environmental awareness [24].

The largest metallurgical enterprise of Kryvyi Rih "ArcelorMittal Kryvyi Rih" for 2006–2018 invested UAH 6.1 billion in environmental protection measures and eco-modernization. Thus, in 2017, the company donated 850 million USD, and in 2018 – more than 5 00 million UAH, in 2019 – about 500 million USD. At the same time, over the next five years, the capital investment of the plant will amount to $ 1.8 billion, in particular in 2019 – about $ 300 million. The total investment of the industrial group "MetInvest" in environmental projects and 2014-2018 amounted to more than $ 1 2 billion, particularly in the 2018 year – $ 92 million. In the first half of 2019, direct investments in environmental activities have increased by 16% of equations with the same period last year – to $ 163 million [25].

However, the efforts mentioned above to address environmental problems do not yet produce the desired result. Air pollution, low water status significantly worsen the health of the inhabitants of the industrial regions. Thus, the incidence in Kryvyi Rih, including cancer, is steadily increasing. As of the end of 2019, 18.5 thousand patients with or suffering from malignant neoplasms are registered at the Kryvyi Rih City Oncology Center [26]. For 2019, 1878 were registered in Kryvyi Rih, who first became ill this year, and according to statistics annually in Ukraine, more than 160 thousand people know that they have cancer [27], so it turns out that every tenth of them is a resident of Kryvyi Rih.

In the Donetsk region, particularly in the war zone, the incidence of pulmonary tuberculosis and acute intestinal disorders has increased significantly, the Ministry of Health of Ukraine draws attention to it. Experts note that infectious diseases are not recorded, but complications can occur due to the destruction of housing and infrastructure, shortages of drinking water and food, lack of proper conditions for compliance with personal hygiene rules [28].

Therefore, despite urban and entrepreneurial conservation efforts and programs, the environmental situation as an indicator of sustainable development in the industrial regions of Ukraine remains dangerous and requires urgent effective action to improve.

4 Intelligent (reasonable) specialization as a new promising strategy for sustainable development of industrial regions

Generalization of the results of theoretical studies on conceptual approaches to sustainable development indicates certain advantages of its environmental component or combination of economic and environmental with particular neglect of the social component. For some time, in particular regarding the prospects of development of the Kryvorizhzhya mining and metallurgical complex, sustainable development has often been considered in the context of stable quantitative growth of raw materials and products, taking into account technological features and adverse effects of cyclically recurring demand for metallurgical products on world markets, environmental safety requirements. However, the use of social resources in achieving the goals of sustainable development and the leverage of social capital was underestimated [29].

Therefore, there is an urgent need to implement new sustainable development strategies based on the use of social and intellectual resources. One of them is the strategy of smart specialization, which is one of the priorities of smart development, which has been actively implemented since 2014, for example, in Poland. Its main

idea is the consensus of science and business, building a market economy based on knowledge, and the introduction of innovative and smart technologies [30].

The main principles of the Intelligent Specialization Strategy, according to Anna Grądziel, are: 1) the creation of a research and innovation sphere of adequate scope, which will allow a large number of organizations to compete with each other in the European Research Area (ERA12), which has an integrated and transnational in nature and allows for free flow of resources; 2) openness and focus on those areas of science and innovation that make up the socio-economic conditions and resources of the region; 3) the presence of so-called general purpose technologies (GPTs) that can serve as additional, but not final, conditions for development; 4) a creative process based on the potential of the region's development, not on an arbitrary decision of the state government [31].

Intelligent (reasonable**,** smart) specialization is impossible without the use of artificial intelligence. S. Russell, P. Norwig rightly paid attention to the development of a specialized multi-level expert system that, by analyzing the content of the information base (which in this case becomes the "knowledge base") by the method of "benchmarking", will be able to identify situations similar to the current ones that were previously, seek management decisions, evaluate and compare their moderation and effectiveness, and generate guidance on any issue [32].

That is, we are talking about the creation at the industrial enterprises and in the industrial regions of such a computer system, which according to E. Timofeev, will be able to assume a number of functions, i.e. to provide multifunctionality of production processes to be able to: identify the most "bottlenecks" at the moment; to predict the condition of the object in the near and long term (condition of equipment wear, depletion of sludge volumes, changing demand for products, investment climate, etc.); to develop recommendations for the development of reconstruction projects, both the whole complex of objects and individual enterprises; to provide advisory assistance in the implementation of specific projects; control the progress of project implementation [16].

According to the researcher, this system must have specific properties, namely accessible the modification of knowledge base, modularity of building a knowledge base and the inference mechanism, high versatility, and security of interface, activity system to update information for the knowledge base. The system should have a mechanism for making probabilistic predictive calculations. Special measures should be taken when designing a database where confidential information can be stored [16].

As noted by M. P. Sagaydak and N. K. Lavrenov, "The players in the mining and metallurgical industry must take on the challenges they face and adapt to new business models of their activities aimed at developing differentiation, stability, and profitability in the value chain. It is important to use digital technologies to solve these problems; however, only some of the metallurgical enterprises have made the necessary changes and realized the important benefits" [33].

Metallurgical enterprises of Ukraine, albeit slowly but still, have begun the process of sincere cooperation of business with scientists with the aim of accelerated modernization and introduction of digital technologies, which is an indicator of intelligent specialization. It is partly due to the Ukrainian steelmakers' Worldsteel rating of the World Steel Association is ranked 11th with an index of 1.9 million tonnes of steel melted (by 2014 Ukraine was in the top ten list and dropped to 13th place during the Donbas war), and only in August 2019 did it further improve its position [34].

The leader of the metallurgical industry of Ukraine and the largest foreign investor in the country JSC "ArcelorMittal Kryviy Rih" proclaimed that it sees its production philosophy to "produce safe environmental steel and therefore in all its operations: from mining of iron ore and steel production products to consumers, guided by a responsible attitude to business, principles of ethics and transparent management" [35]. In 2019 at the plant started hot testing of the reconstructed state-250-4, power which will increase from 800 000 to 1.04 million tons per year, and emissions will be reduced by 131 tons. The cost of the renovation was $ 50 million. In the next five years, ArcelorMittal plans to direct $ 1.8 billion in production development. Among its major projects is the construction of a pellet factory. It will allow the abandonment of obsolete agglomerate production and reduce hazardous emissions by 50-55% [34].

"Smart" technology "Mobile traffic light" was introduced at the metallurgical plant "Zaporizhstal" for operational monitoring of production processes: the shop hot-rolled thin sheet in a pilot mode with 2 000 sensors that can read 130 000 parameters of the equipment. The program makes it possible to make a prompt decision on the timely completion of the necessary repair works : the percentage of wear, frequency of replacement of parts, service life, speed of defect development, etc. is calculated , it is envisaged to collect and record in a single electronic database the condition of equipment in all shops. About the same system has been operating at the Interpipe Steel plant (Dnipro) since 2016 – this is the Smart module EAM for the maintenance and repair of equipment, which contains all information about the essential equipment of the plant, including drawings, repair maps of each site. As a result, the number of accidents at work decreased from 2% to 0.3%, the volume of defective products at the equipment emergency stop decreased all the time, the stock of spare parts in the warehouse decreased by 10%, and the overall efficiency of the equipment increased by 10-15%. Now Interpipe is introducing another system – Smart.Factory is a cross-cutting and production planning project. The system is built based on Industrial Internet of Things (IoT) technology – information about each product (e.g., melting point, steel grade, order number, etc.) is stored in a single database. Interpipe tests this system for pipe production, but it can be adapted to any enterprise. Moreover, in the near future, such modules will appear at other metallurgical plants [34].

Scientists have long been discussing fundamentally new technology, namely, the production of iron ore and metal using hydrogen. In some places, this technology is already used for ore enrichment, but it is not in a hurry to introduce it at Ukrainian plants because of its high cost.

Therefore, it should be emphasized that the enterprises of the industrial regions of Ukraine, including Kryvyi Rih in the last years, have started the modernization process, which uses the components of intelligent specialization, but this is not enough. Tactically, they are affected by socio-environmental problems because of the need to respond to changes in consumer needs that reflect their concerns about the consequences of their industrial activities. However, in the long-term plans, the desire for sustainable development requires fundamental changes in the management paradigm, which is embedded in the mission of enterprises and which will ensure the full implementation of smart specialization.

Today, the goals of modern Ukrainian enterprises, based on the concept of sustainable development, combine environmental concerns with stimulating and encouraging consumers to increase profits and therefore view resources as an endless source of raw materials. However, it is worthwhile to change management approaches based on the fact that the new strategy of smart specialization will help to form new intelligent thinking, reasonable needs, and therefore change the structure of consumption and balance natural processes.

Within the framework of smart specialization, successful operation is ensured for enterprises that will apply long-term, environmentally friendly processes, introduce innovative technologies and products that have competitive advantages. Intellectual specialization itself needs to perceive sustainable development as a coherent philosophy, where environmental problems and responsibility for them are fully integrated into the life cycle of not only products but the entire system of economic activity. Specialized distribution channels are laid to work with niche consumers. The mission of enterprises must be developed based on sound environmental awareness [36].

There is no doubt that the introduction of the concept of smart specialization meets the needs and capabilities of the Kryvyi Rih region, as it has sufficient scientific, human, natural, and technological capital and potential for it. However, for this, it is necessary first of all to create a positive image of the region in the eyes of foreign investors through the development of environmental marketing. According to O. V. Latysheva, environmental marketing, which is formed on the principles of social and ethical marketing, aims to resolve the contradictions between the production and preservation of the environment [37]. Analyzing the attitude of leading foreign firms and companies to the environmental, and therefore social consequences of their activities, the researcher summarizes five main reasons for the importance of environmental marketing, in particular: considering it as an opportunity to achieve strategic goals; enhancing the moral obligations of economic entities to be more socially responsible to society; governmental control over the responsibility of enterprises, firms, companies for their activities; the influence of environmental actions of competing firms on environmental marketing policies and changes in the attitude of economic agents to the environment under the influence of cost factors related to pollution or scarcity of resources [37].

Secondly, as V. Vasylenko rightly points out, remote sensing of the earth - the latest method of environmental monitoring, which is the most accessible method of obtaining reliable information about the state of the environment in large territories due to the large amount of open data and free software for their processing, needs to be introduced and has a huge range of applications: ecology, construction, site planning, etc. [38]. It is worth agreeing with the researcher's view that in order to intensify the use of such monitoring methods, it is necessary to bring geospatial information used in Ukraine to the level of international standards, first of all by implementing the INSPIRE directive, which establishes general rules for the creation of geospatial and information infrastructure and enhances the qualification of users public information, especially at the state level.

5 Conclusions

Thus, sustainable development is a global economic and socio-environmental strategy, the main idea of which is to understand the need for change not only in the activities of industrial enterprises but also in the public consciousness of people and the culture of using natural resources. The focus of humanity is on the holistic and integrated priorities of the relationship between the economy, the environment, and society; physical stability of processes, their social acceptability; globality, not specific urgent challenges. At the same time, socio-environmental strategies are calculated not only for the long term but for an unlimited period when environmental care is considered not as a benefit to society but as an intrinsic, real, actual value.

At the same time, the analysis of the implementation of sustainable development strategies in Ukraine, in particular in large industrial regions, for example, in the Kryvyi Rih iron ore basin and the Donetsk industrial region, shows that there are many unresolved social and environmental problems.

Therefore, the *novelty of the scientific study* of the implementation of the strategy of sustainable development in industrial regions of Ukraine and opportunities for the introduction of smart specialization is as follows: firstly, it is found that significant positive changes in the environmental and socio-economic status of regions did not occur during its implementation period; secondly, the reasons for the lack of effective implementation of the sustainable development concept have been identified, yes which include the following: ineffective management of industrial regions; insufficiency innovation-investment component of sustainable development and its implementation; loss and / or ineffective recovery scientific-industrial relations between scientific institutes and business structures; absence sufficient and up-to-date government support for sustainable development through appropriate financial

and programmatic support resources; hostilities in eastern Ukraine; the unformed ecological paradigm of education, and therefore the ecological one the consciousness and culture of the population of the industrial regions, in particular the youth; thirdly, based on an analysis of Polish experience, it is justified that an effective strategy that can give a new impetus to activate sustainable development in the industrial regions of Ukraine, is the concept of intelligent regional specialization, which envisages deepening of cooperation of scientists and entrepreneurs; development and implementation of a set of new environmental standards for production; the development of innovative, in particular digital technologies that enable the efficient use of human and natural resources; improving the management paradigm; introduction of systematic environmental monitoring; division of responsibilities between authorities and business through the development of cooperation; formation of new ecological thinking and reasonable culture of consumption in society at the expense of educational activity and creative activity of young scientists and scientists.

Therefore, a promising area of research for the sustainable development of industrial regions is the elucidation of the specifics and factors that will accelerate the introduction of intelligent specialization in the production processes of mining and metallurgical production.

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