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IMPACT OF INNOVATIVE TECHNOLOGIES ON THE MANAGEMENT FORMAT UNDER CONDITIONS OF SUSTAINABLE DEVELOPMENT

ВПЛИВ ІННОВАЦІЙНИХ ТЕХНОЛОГІЙ НА ФОРМАТ МЕНЕДЖМЕНТУ В УМОВАХ СТАЛОГО РОЗВИТКУ

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For modern management systems, the impact of radically new or improved technologies is becoming increasingly significant as they become key factors in the transformation of management. The outlined significance is because every social, ecological, or economic innovation is essentially an idea or product that changes the set of methods, techniques, tools, and management procedures, correcting or accelerating the evolution of the theory and practice of sustainable development. In this context, the format of sustainable development management is formed, which acts as a platform for broadcasting the innovative triune impact on the system of managing economic activities. Thus, the article aims to study the impact of innovative technologies on management format in the context of sustainable development. The research findings prove that the integration of innovative technologies into management is carried out through the main management functions, which creates opportunities to adjust and optimize resource use in response to changing ecological, social, and economic conditions.

Keywords: management systems, economic goals, social goals, Hicks-Lindahl income, statistical methods, econometric models.

Для сучасних систем управління дедалі більшого значення набуває вплив радикально нових або вдосконалених технологій, які стають ключовими чинниками трансформації менеджменту. Окреслена значущість зумовлена тим, що кожна соціальна, екологічна чи економічна інновація є, по суті, ідеєю або продуктом, який змінює сукупність методів, прийомів, інструментів і процедур управління, коригуючи

або прискорюючи еволюцію теорії та практики сталого розвитку. У такому контексті формується формат менеджменту сталого розвитку, який є панеллю для транслювання інноваційного триєдиного впливу на систему управління господарською діяльністю. Відтак, метою статті є дослідження особливостей впливу інноваційних технологій на формат менеджменту в умовах сталого розвитку. За результатами дослідження встановлено, що інтеграція інноваційних технологій у менеджмент відбувається через основні функції управління, що створює можливості для налаштування та коригування використання ресурсів відповідно до змінних екологічних, соціальних та економічних умов. Констатовано, що процес інтеграції інноваційних технологій має охоплювати такі основні напрями: зміну порядку дій із збереження капіталу, трансформацію організації процесів сталого розвитку та модифікацію контролю за процесами сталого розвитку. Зміна порядку дій із збереження капіталу відбувається тому, що сталий розвиток вимагає ефективного збереження та відновлення природних ресурсів. Зокрема, це включає перенаправлення частини прибутку від продажу невідновлюваних ресурсів на інвестиції у збільшення цінності відновлюваного природного капіталу. Зміна організації процесів сталого розвитку є важливою через необхідність збереження та відновлення екологічного капіталу на довгострокову перспективу. Зміна контролю процесів сталого розвитку є важливою через необхідність оцінювання ефективності поточних процесів, а також забезпечення прозорості та підзвітності у використанні ресурсів і досягненні економічних та соціальних цілей. Перспективи подальших досліджень полягають у аналізі ефективності інтеграції новітніх інноваційних технологій у різні аспекти менеджменту сталого розвитку, з метою забезпечення більш гнучкого та результативного адаптування до глобальних екологічних, соціальних та економічних викликів.

Ключові слова: системи управління, економічні цілі; соціальні цілі, дохід Хікса-Ліндаля, статистичні методи, економетричні моделі.

Problem statement. For modern management systems, the impact of radically new or improved technologies is becoming increasingly significant as they emerge as key drivers of management transformation. The outlined significance is driven by the fact that every social, environmental, or economic innovation is essentially an idea or product that alters the set of methods, techniques, tools, and procedures of management, thereby adjusting or accelerating the evolution of the theory and practice of sustainable development [4]. In this context, the format of sustainable development management is formed, acting as a platform for transmitting the innovative triune impact on the management system of economic activity, which occurs through the lens of specificity, clarity, realism, and its connection to time. We emphasize that such an impact requires enterprises to adopt new approaches to the construction of planning, organization, and control processes at the points of formation of the Hicks-Lindahl aggregate income flow (within which the most important aspect is the maximum preservation of aggregate capital, through which this income is generated).

Analysis of research and publications. The issues of optimizing the management format in sustainable development have been actively studied by both domestic and foreign scholars. Authors such as Dyachenko V. S. [1], Kyfiak V. [3], Ulyanova L., and Chayka Yu. have made significant contributions to the development of these issues. [5], Chorna M. V., Kukhlenko O. V. [6], Schumpeter J. [8]. However, despite the presence of numerous studies in this field, the specifics of the impact of innovative technologies on the management format in the context of sustainable development remain insufficiently explored. The lack of attention to these aspects creates a methodological gap that requires further research. In particular, the integration of cutting-edge digital solutions into core management functions, the adaptation of modern technologies to environmental requirements, and other related issues remain highly relevant.

Formulation of the article's objectives. The article aims to study the impact of innovative technologies on management format in the context of sustainable development.

The paper main body. Within the framework of the study, the authors highlight the fact that sustainable development management is shifting its format from a classical to a flexible one through the integration of innovative technologies into its core processes, which shape the Hicks-Lindahl income. At the same time, we agree with the views of Chorna M.V. and Kukhlenko O.V. [6] that radically new and improved technologies have a special impact on the theories and practices of management, creating opportunities for adjusting and fine-tuning the conditions for sustainable development through:

1. Changing the order of actions regarding capital preservation (priority should be given to actions where a portion of the profit from the sale of non-renewable resources is directed on the value of renewable natural capital increasing).

2. Changing the organization of sustainable development processes (through the new approaches to organizing production and management processes implementation, including consideration of environmental, social, and economic factors).

3. Changing the control of sustainable development processes (through new control methods implementation that assesses the effectiveness of current processes, ensures transparency and accountability in resource use, and the achievement of economic and social goals).

Thus, regarding new planning formats, they will take into account the full spectrum of directions that define the flows of Hicks-Lindahl aggregate income (specifically actions related to resource use, as well as environmental – nature, energy, and material-saving technologies [2–3]).

At the same time, it should be noted that for planning the flow of aggregate income within the context of the Hicks-Lindahl theory, priority is given to the following groups of innovative technologies (see Table 1): optimization of resource allocation (specifically linear programming and dynamic programming), maximization of aggregate welfare (general equilibrium models and scenario models), efficiency analysis (cost-benefit allocation method and economic efficiency method), demand forecasting and production planning (statistical methods and econometric models), and modeling of income and expenses based on the Hicks-Lindahl theory.

It is evident that in sustainable development management, it is important to apply planning technologies that ensure the optimization of resource allocation through the iterative solution of the task of maximizing economic outcomes, which are formed based on the principles of the Hicks-Lindahl theory. For example, the Khortytsia distillery produces goods using energy, materials, labor, and capital investments. Therefore, to achieve sustainable development, its management takes into account the volumes of renewable and non-renewable resource use through linear programming for each type of product produced. The linear programming model for "Khortytsia DE LUXE" can be as follows:

$$\text{Maximization of profit} = \sum_i (\text{Profit from product } i \times x_i), \quad (1)$$

where **xi** is the number of units of resource used in the production of the "Khortytsia DE LUXE" product, taking into account all constraints, such as: limitations on the amount of available energy from renewable and non-renewable sources, the availability of human resources, materials, and capital.

During the planning process, the main focus is directed toward: 1) determining the paths along which capital should be preserved; 2) determining the extent to which different types of capital are interchangeable. In addition, the management of Khortytsia also applies a cost-based assessment of assets, which is incorporated into the formation of the Hicks-Lindahl income flow.

New formats for organizing the Hicks-Lindahl aggregate income flows define models for the extraction and processing of raw materials, the creation of environmentally acceptable products, as well as the minimization, recycling, and disposal of waste.

Thus, to implement the function in the outlined area, priority is given to the following groups of innovative technologies (see Table 2): sustainable resource extraction and use (model for reducing the environmental impact of extraction, resource recovery models, models for transitioning to alternative energy sources [7]); ecological waste recycling (waste sorting automation model, secondary waste recycling model [2]); creation of environmentally clean products (model for using renewable materials, energy-efficient production process model, closed-loop production model [5]); minimization of waste and its recycling (organic waste composting model, thermochemical waste recycling model, smart waste management systems [2]).

The Hicks-Lindahl model defines total income as the result of the interaction of economic agents within the framework of rational consumption and optimal production. For example, in the sustainable development management of the SHEMAX company, processes have been implemented that ensure the targeted, programmable impact of specific innovative technologies on achieving the goal of forming and maximizing income streams, with a focus on weak sustainability (when natural and production capital is diminishing over time) and strong sustainability (when alternative capital must increase). In particular, in 2021, a program for the use of energy-efficient innovative technologies was implemented (within which a portion of the profit from product sales is directed towards upgrading production capacities, such as solar panels and heat recovery systems installation).

New process control formats for sustainable development emphasize income stream formation based on the Hicks-Lindahl model. To implement the function in the outlined area

Table 1

Features of the Impact of Innovative Technologies on the Planning Process in Sustainable Development Management of an Enterprise

Groups of planning technologies	Specific Technologies		Impact of innovative technologies on the planning process
	Title	Features of Use	
Optimization of resource allocation	Linear Programming	It is used for the optimal allocation of resources within an enterprise, taking into account production constraints and the maximization of income or profit.	Increase in the accuracy of resource demand forecasting, improvement in the efficiency of their allocation [1]
	Dynamic Programming	It is used to optimize resource utilization, considering demand and supply.	
Maximization of aggregate welfare	General equilibrium models	It is used to determine optimal prices and production volumes that maximize aggregate income and meet the needs of all participants.	Contributing to a more transparent and equitable distribution of economic benefits among all participants in the process [2]
	Scenario Models	It is used to optimize the enterprise's income flows, taking into account changing demand, investments, and production capacities.	
Efficiency analysis	Cost-Benefit Allocation Method	It is used to assess the impact of different business strategies on Hicks-Lindahl's aggregate income.	Contributing to the assessment of the effectiveness of current processes and the forecasting of potential disruptions or inefficiencies in future expenditures [3]
	Economic Efficiency Method	It evaluates economic efficiency by comparing production and sales costs with the Hicks-Lindahl income generated.	
Forecasting and planning product demand	Statistical Methods	It forecasts future demand for products and services, allowing enterprises to adjust their production capacities and sales strategies to maximize income.	Allowing for more accurate forecasting of changes in demand and consumer behavior [4]
	Econometric Models		
Modeling of income and expenses	Studies of models formed based on the hicks-lindahl theorem	It is used to determine the optimal supply level that achieves a balance between costs and revenues, ensuring the maximization of Hicks-Lindahl's aggregate income.	Allowing businesses to create more accurate forecasts of income and expenses [5]

Note

1. For example, modern enterprise management systems (ERP) can integrate information about available resources, costs, and demand in real time, allowing managers to make optimal decisions to reduce costs and increase efficiency.
2. For example, reducing transaction costs and ensuring more efficient income distribution, which in turn increases overall aggregate welfare.
3. For example, creating opportunities to respond more quickly to changes.
4. For example, creating opportunities to improve the understanding of new trends and the enterprise's responsiveness to market changes.
5. For example, creating opportunities to account for various economic, social, and environmental factors, contribute to more accurate modeling of the impact of different scenarios on aggregate income.

Source: compiled based on [2–3; 5; 7]

following groups of innovative technologies are prioritized (see Table 3): the system of key parameters of Hicks-Lindahl income (balanced sustainability indicators model, models for data collection and processing related to sustainable development [7]); the model for controlling the distribution of Hicks-Lindahl income along value chains (ERP systems for income management

Table 2

Features of the impact of innovative technologies on the planning process in sustainable development management of an enterprise

Groups of organizational technologies	Specific Technologies		Impact of innovative technologies on the organization process
	Title	Features of Use	
Sustainable extraction and use of resources	Model for reducing the environmental impact of extraction	Use of low energy consumption equipment, reduction of emissions and waste	They enable the optimization of resource use, reduction of environmental impact, decrease dependence on fossil fuels, and cost reduction.
	Resource recovery model	Used water, land, and other natural resource recovery	
	Model for transitioning to alternative energy sources	Use of solar, wind, and geothermal energy	
Ecological waste recycling	Waste sorting automation model	Used for integrating sensor technologies and AI for waste sorting	They enable increased efficiency in waste recycling and reduce the costliness of the process.
	Secondary waste Recycling model	Use of innovative methods for recycling polymers, metals, and glass	
Creation of environmentally clean products	Model for the use of renewable materials	Used for replacing synthetic materials with biodegradable and renewable ones	They enable the enhancement of product eco-friendliness and improvement of the company's image.
	Energy-efficient production process model	Used for reducing energy consumption during production	
	Closed-loop production model	Used for designing products for easy disassembly and reuse	
Minimization of waste and its recycling	Organic waste composting model	Used for transitioning to aerobic and anaerobic hrocesses for organic recycling	Reduction of waste volumes, production of biogas and fertilizers, and improvement of waste management efficiency..
	Thermochemical waste recycling model	Used for transitioning to pyrolysis, gasification, and plasma recycling	
	Smart waste management systems	Used for monitoring and predicting waste volumes using IoT and AI	

Source: compiled based on [1-2; 5-7]

along value chains, blockchain technologies to ensure financial flow transparency [7–8]); digital twins of Hicks-Lindahl income streams (or virtual copies of each Hicks-Lindahl income stream [7]).

Thus, in sustainable development management, technologies should be applied that allow owners and managers to adjust the processes of generating Hicks-Lindahl aggregate income flows in real time, taking into account that not all types of capital are interchangeable. In particular, EKTA uses an ERP (Enterprise Resource Planning) system that integrates data on financial resources, natural capital, production capacities, and product demand in real-time. Using this system, managers can track the quantity and quality of natural resources used (such as water or energy) and their impact on production.

Conclusions. The research findings prove that innovative technology integration in management is carried out through the main functions of management, which opens up

Table 3

Features of the impact of innovative technologies on the control process in sustainable development management of an enterprise

Control technology groups	Specific Technologies		The impact of innovative technologies on the control process.
	Title	Features of Use	
System of core parameters of hicks-lindahl income	**Balanced model of sustainability indicators** (practical and measurable indicators)	Used for measuring, monitoring, and analyzing economic indicators that reflect the total income within the framework of the Hicks-Lindahl model.	They identify core parameters such as productivity, resource efficiency, and income levels for sustainable development planning.
	Models for data collection and hrocessing regarding sustainable development		They allow data integration from various sources to analyze and forecast income, enabling more accurate assessment of income streams and strategic planning.
Model of control of hicks-lindahl income distribution along value chains	ERP Systems for managing income along value chains	Used for automating the management of financial flows at various stages of production.	They ensure transparency and accurate control over the income distribution among participants in the production and economic chains. This allows for the optimization of costs and the improvement of process efficiency.
	Blockchain technologies for ensuring transparency of financial flows	Used for ensuring the transparency of financial flows	They help increase trust and reduce risks associated with financial flow manipulation by creating a transparent system for income distribution and effective resource management.
Digital twins	*Virtual copy of a single hicksh-lndahl income flow*[1]	Used for modeling, monitoring, and optimizing sustainable development.	They allow the creation of accurate replicas of economic systems, which help monitor, evaluate, and optimize income flows for sustainable business development in real-time

Note

1. A conceptual tool or model that reflects all income and expense flows arising from economic activity, but within a context where they have not only an economic but also an ecological and social component.

Source: compiled based on [3; 5; 7-8]

opportunities to adjust and optimize the use of resources by changing environmental, social, and economic conditions. It has been proven that the process of integrating innovative technologies should include the following core areas:

1. Changing the approach to capital preservation. Since sustainable development requires effective conservation and restoration of natural resources, it is crucial to redirect part of the profit from the sale of non-renewable resources to investments in increasing the value of renewable natural capital. It involves the development of new technologies and resource management methods that enable the preservation and restoration of ecological capital for the long term.

2. Changing the organization of sustainable development processes. In the enterprise sustainable development, it is essential to adopt new methods for organizing production and management processes while considering environmental, social, and economic factors. It allows for the creation of adaptive management strategies that can respond promptly to changes in the environment, reducing negative impacts on nature and society.

3. Changing the control of sustainable development processes. The implementation tasks of new control methods are to assess the effectiveness of current processes and ensure transparency and accountability in the use of resources, as well as in achieving economic and social goals. Modern control technologies adoption helps ensure the high effectiveness of sustainable development through regular monitoring and adjustment of strategies.

Thus, innovative technologies play a key role in transforming management, ensuring its ability to adapt to the demands of sustainable development. In this context, the prospects for future research lie in studying the effectiveness of integrating the latest innovative technologies into various aspects of sustainable development management to ensure more flexible and effective adaptation to global ecological, social, and economic challenges.

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