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CHAPTER 20
SYNERGISTIC INTERACTION BETWEEN HUMAN AND NATURAL CAPITAL WITHIN A SUBJECT-CENTRIC FRAMEWORK: IMPLICATIONS FOR MANAGEMENT ACCOUNTING AND ECONOMIC SECURITY

Yuliia Nezhyd

INTRODUCTION

Modern transformational processes in the economy, driven by increasing geopolitical instability, wartime challenges, globalization shifts, and the growing importance of sustainable development, have intensified the need to ensure the economic security of enterprises at a fundamentally new level. Under conditions of heightened uncertainty, traditional drivers of economic growth are gradually losing their decisive role, while intangible and ecosystem-based resources – particularly human and natural capital – are becoming critically important, forming the foundation of long-term resilience of business entities.

Within the contemporary scientific paradigm, human capital is recognized as a key driver of the creation and development of an innovation-driven economy [1]. At the same time, alongside human capital, the importance of natural capital is increasing as an integral component of the economic system. The natural environment is increasingly conceptualized as a form of capital asset – identified as natural capital – which provides the resource base for production processes and shapes the environmental component of enterprise value [2].

At the same time, existing approaches to managing human and natural capital are largely fragmented and fail to ensure their comprehensive integration within the enterprise economic security management system. This is particularly evident in accounting and analytical support, which is traditionally oriented toward financial indicators and does not fully capture the

[1] Пищуліна О., Юрочко Т., Міщенко М., Жаліло Я. Розвиток людського капіталу: на шляху до якісних реформ. Київ : Центр Разумкова. Вид. «Заповіт». 2018. 367 с. URL: https://razumkov.org.ua/uploads/article/2018_LUD_KAPITAL.pdf

[2] Barbier E. B. The concept of natural capital. *Oxford Review of Economic Policy*. 2019. Vol. 35, no. 1. P. 14–36. DOI: https://doi.org/10.1093/oxrep/gry028

interrelationships between different types of capital, their impact on enterprise resilience, and the capacity to adapt to external challenges.

In this context, the concept of synergistic interaction of capitals gains particular relevance, as it implies the creation of added value through the integrated use of human and natural capital. Such an approach enables economic security to be interpreted not only as protection against risks, but also as the capacity for sustainable development through effective resource management. At the same time, the issue of subject-centricity in the processes of capital formation and utilization remains insufficiently explored. This concept involves the identification of key actors, their roles, interests, and influence on resource management. The lack of a clear understanding of the subject structure leads to reduced effectiveness of managerial decision-making, increased information asymmetry, and heightened risks within the economic security system.

Management accounting plays a crucial role in ensuring the synergistic interaction of human and natural capital, serving as a key instrument for generating relevant information to support managerial decision-making. Contemporary trends in the development of accounting systems – particularly in the context of integrated reporting and sustainability requirements – necessitate the transformation of management accounting toward expanding its functional capabilities to capture non-financial aspects of enterprise performance.

Thus, the relevance of this study is determined by the need to develop theoretical and methodological foundations for the synergistic interaction of human and natural capital based on the principles of subject-centricity within the management accounting system for ensuring enterprise economic security. The aim of this section is to substantiate conceptual approaches to the integration of human and natural capital within the management accounting framework of enterprise economic security and to advance capital theory through the lens of subject-centricity and their synergistic interaction.

20.1. Institutional Determinants of the Development of Management Accounting as a Tool for Ensuring Enterprise Economic Security

The formation of enterprise economic security under contemporary business conditions is shaped by a complex and multi-level institutional environment that defines the rules, norms, and constraints governing the functioning of economic actors. A leading representative of institutional theory, Nobel laureate D. North, conceptualizes institutions as a system of formal and informal constraints and their enforcement mechanisms “the rules of the game”

that structure interactions among economic actors and reduce uncertainty in the functioning of economic systems.[3]. At the same time, the methodological foundations of institutionalism were laid in the works of its classical representatives, in particular T. Veblen, who substantiated that the institutional paradigm is grounded in the principles of evolutionary change and the development of socio-economic life [4].

Academician of the National Academy of Agrarian Sciences of Ukraine, V. Zhuk, emphasizes that institutions form the framework conditions within which economic activity is carried out, managerial decisions are made, and the stability of enterprise functioning is ensured [5].

In turn, S. Vasylishyn extends the institutional approach within the domain of economic security, substantiating that the accounting institution – represented by a set of formal and informal institutions as well as professional entities at different levels – serves as a primary source of institutional support for economic security within the existing regulatory and legal framework [6].

In this context, the informational function of accounting becomes particularly significant, as noted by O. Petruk and S. Vasylishyn, who argue that the accounting system, as an institutionally conditioned information mechanism, ensures the generation of relevant data for risk assessment and supports managerial decision-making in the field of enterprise economic security [7].

In the context of ensuring enterprise economic security, institutions perform a key function in regulating economic behavior by defining the permissible boundaries of resource utilization, the nature of stakeholder interactions, and the mechanisms for responding to risks. Their influence is realized through a system of formal and informal constraints, including regulatory and legal acts, standards, and regulations, as well as established practices, corporate culture, and ethical principles of doing business.

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[3] North D.C. Institutions, institutional change, and economic performance. Cambridge: Cambridge University Press, 1990. 152 p.

[4] Veblen T. The Theory of the Leisure Class: An Economic Study of Institutions. New York : B. W. Huebsch, 1918. 184 p.

[5] Жук В.М. Концепція розвитку бухгалтерського обліку в аграрному секторі економіки: монографія. Київ : ННЦ «Інститут аграрної економіки» УААН, 2009. 648 с.

[6] Василішин С. І. Обліково-аналітичне забезпечення в системі ризиків та загроз економічної безпеки аграрних підприємств України: монографія. Харків. нац. аграр. ун-т ім. В.В. Докучаєва. Харків : ТОВ «Друкарня Мадрид», 2020. 419 с.

[7] Петрук О. М., Василішин С. І. Інституціональні фактори обліково-аналітичного забезпечення управління економічною безпекою підприємств. *Проблеми теорії та методології бухгалтерського обліку, контролю і аналізу*. 2021. № 3(47). Р. 47–55.

As noted by I. Ruzhytskyi, institutional determinants of economic security regulation form an integrated system, the effectiveness of which is ensured through the implementation of functions related to the development of institutional infrastructure, the stimulation of innovation activity, investment activity, risk insurance, and the improvement of the regulatory and legal environment [8].

Thus, institutional determinants encompass not only regulatory aspects, but also the mechanisms of resource, innovation, and informational support for enterprise economic security.

In order to systematize the structure of the institutional environment, it is appropriate to consider it as an integrated model comprising three key components: formal institutions, informal institutions, and organizations as agents of institutional change (Fig. 1).

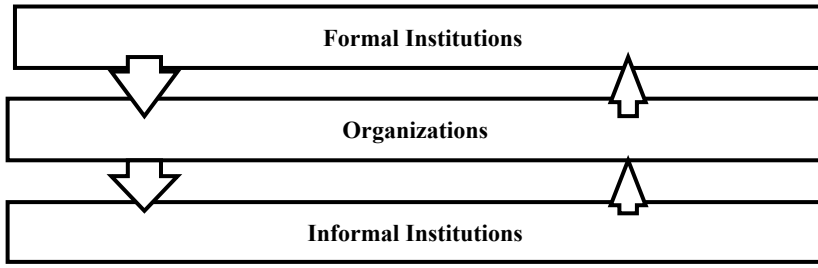

Figure 1. Model of the Socio-Economic Institution

Source: developed by the author based on [29]

According to the proposed model, the institutional environment is conceptualized through the interaction of institutional poles – formal and informal institutions, as well as organizations that ensure their practical implementation and transformation. In this context, organizations act as active agents of institutional change by introducing managerial practices, policies, and innovations that adapt institutions to the conditions of a dynamic economic environment.

It is important to emphasize that the institutional environment is not a static construct but is characterized by the capacity to evolve under the influence of technological, social, and environmental transformations. In this context, management accounting serves as a key instrument of institutional adaptation

[8] Ружицький І. Інституційне регулювання економічної безпеки України: теорія, методологія, практика : автореф. дис. … д-ра екон. наук : 08.00.03. Львів, 2021. 41 с.

of the enterprise to conditions of uncertainty and risk, as it enables the transformation of institutional requirements into relevant information for managerial decision-making. As noted in the literature, the contemporary trajectory of management accounting development reflects its transformation into a proactive, data-driven system capable of supporting dynamic forecasting and enhancing enterprise adaptability to external challenges [9].

Institutional determinants shape not only the content of accounting information but also the approaches to its generation and use within the enterprise economic security management system. The functional role of management accounting is transforming from traditional cost calculation toward the development of an analytical framework capable of identifying potential threats. A detailed analysis of the impact of institutional factors on management accounting and economic security at different levels is presented in Table 1.

At the same time, under contemporary conditions of economic system transformation, institutional determinants influence not only the organization of accounting as a process but also the approaches to identifying its objects. Among these, human and natural capital are of particular importance. These forms act as key carriers of risk and fundamental sources of value creation, which objectively necessitates their integration into the management accounting system for analytical assessment and the provision of enterprise economic security.

Within such an institutional environment, the direct interaction between key types of capital is formed and realized. Relevant institutions determine:

– the rules governing the formation and reproduction of human capital (education standards, competency development, motivation systems, and social guarantees);

– the mechanisms for the use and preservation of natural capital (environmental regulations, resource-use restrictions, and principles of socially responsible natural resource management);

– the conditions for their integration within the continuous process of value creation.

Thus, the institutional environment acts not only as a general regulator of economic activity but also as a determining factor in shaping the synergistic interaction of human and natural capital. It establishes the parameters of their effective integration, which directly affects the level of enterprise economic security.

[9] Багрій К., Вдовічен А., Шеверя Я. Розвиток управлінського обліку в контексті Індустрії 4.0. *Актуальні питання економічних наук*. 2025. Вип. 17.

Table 1

Impact of the Institutional Environment on Management Accounting and Enterprise Economic Security

Level of Institutional Influence	Group of Factors	Nature of Impact on Management Accounting	Manifestation in the Economic Security System
Macro Level	Political and Legal Factors	Establishment of regulatory requirements for accounting policies, standardization of control procedures, and information disclosure	Ensuring compliance and mitigating regulatory risks
	Economic Factors	Determination of operating conditions, level of competition, and access to resources	Impact on financial stability and assessment of external risks
	Social Factors	Formation of the professional environment, ethical norms, and behavioral patterns	Reduction of opportunistic behavior risks and enhancement of trust
	Technological Factors	Development of digital solutions and automation of accounting processes	Improvement of information timeliness and strengthening of cybersecurity
Meso Level	Market Environment	Influence of competitors, counterparties, and investors on the structure of information demands	Identification of market risks and adaptation of managerial decisions
	Industry-Specific Factors	Specific features of accounting objects, costs, and business processes	Formation of industry-specific risks and mechanisms for their control
	Interaction Institutions	Contractual relations, partnerships, and investment linkages	Management of contractual risks and enhancement of operational reliability

Micro Level	Management	Determination of managerial information needs and development of internal control systems	Improvement of decision-making quality and risk prevention
	Resources	Structure and efficiency of resource utilization	Control of resource-related risks and cost optimization
	Personnel	Level of competence, professional judgment, and responsibility of staff	Reduction of internal risks and enhancement of information reliability
	Information	Quality, timeliness, and security of information flows	Ensuring information security and analytical support

Source: compiled by the author

20.2. Theoretical and Methodological Foundations of the Synergistic Interaction between Human and Natural Capital within the Management Accounting System for Ensuring the Economic Security of an Economic Entity

Modern transformational processes in the economy, driven by globalization challenges, tightening environmental constraints, technological dynamics, and the growing role of the knowledge economy, necessitate a reconsideration of traditional approaches to the identification and assessment of factors ensuring the economic security of enterprises. Under these conditions, particular importance is attached to the study of the role of various forms of capital as key carriers of value, sources of risk, and powerful drivers of development.

As substantiated earlier, management accounting operates within an institutional environment that determines approaches to the formation, processing, and use of information for managerial decision-making. At the same time, institutional determinants influence not only the organization of accounting processes but also the conceptual approaches to the identification of accounting objects. Among these, increasing attention is being paid to the expansion of capital theory, particularly in the context of the subject-based nature of human and natural capital.

The theoretical foundations for considering human capital as an active subject of value creation were established as early as the 1960s by the American economist G. Becker, who demonstrated that investments in training,

education, and health enhance the productivity of individuals, the economy, and society as a whole[10]. Modern instruments for measuring such productivity include both hard and soft skills: the level of formal education, the quality of professional training, technical competencies, the capacity for lifelong learning, as well as indicators of physical health and social skills.

This approach is fully aligned with global institutional benchmarks. In particular, World Bank, within the framework of the Human Capital Project, emphasizes the key role of investments in health and quality education in shaping the long-term productivity of the workforce, which, accordingly, constitutes a prerequisite for enhancing the competitiveness of both individual enterprises and the national economy as a whole [11].

It is also advisable to consider the approach presented in the works of authors led by E. Libanova, according to which, under modern conditions, socio-economic policy is undergoing a transformation from a model of passive social protection to an activation paradigm. This paradigm is based on investment in human capital and involves treating human capital as a dynamic category, the development of which is ensured through the stimulation of employment, enhancement of economic activity, and the integration of individuals into productive economic processes [12]. This perspective makes it possible to interpret human capital not merely as a resource, but as a key factor in ensuring the resilience and economic security of an enterpris.

In the domestic scientific discourse, the concept of human capital is also examined through the lens of spatial and sectoral development. In particular, L. Pronko explores the definition of "human capital of rural areas," interpreting it as a multi-component socio-economic system that integrates the educational and professional as well as medico-demographic characteristics of the population with social, cultural, and institutional dimensions. Its role is manifested in shaping labor productivity, ensuring territorial development, and enhancing the resilience and adaptive capacity of communities under conditions of structural and crisis transformations [13].

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[10] 10. Becker G. S. Human Capital: A Theoretical and Empirical Analysis. Third Edition. The University of Chicago Press, 1993. 380 p. URL: http://digamo.free.fr/becker1993.pdf

[11] Лібанова Е.М., Макарова О.В., Саріогло В.Г. Політика активізації як інвестиція у людський капітал: теорія і практика. *Наука та інновації*. 2020. Т. 16, № 5. С. 57–68. DOI: https://doi.org/10.15407/scin16.05.057

[12] World Bank. Human Capital Project / Human Capital Index. URL: https://www.worldbank.org/en/publication/human-capital

[13] Пронько Л. Організаційно-економічний механізм відтворення людського капіталу сільських територій: дис. … д-ра екон. наук : 08.00.03. Вінниця, 2026. 729 с.

Human capital also plays a crucial role in the system of ensuring the economic security of an enterprise. In particular, I. Rekun emphasizes that the formation of economic security requires the search for more effective directions of enterprise activity, taking into account contemporary challenges. This objectively necessitates the improvement of personnel strategy and the expanded development of human capital based on progressive forms and methods of human resource management [14].

The analysis of scientific approaches to the interpretation of human capital indicates the dominance of the resource-based (factor) approach, within which its formation is primarily considered as the result of the linear influence of individual economic, social, or institutional factors. At the same time, such an approach does not fully provide a comprehensive understanding of the mechanism through which a human asset is transformed into effective capital that directly participates in value creation and ensures the economic security of an enterprise.

To overcome this methodological gap, particular attention should be paid to the role of the economic entity as the key integrator of these processes. It is precisely at the level of the enterprise that a complex combination of the individual's internal characteristics, the outcomes of their educational and professional development, and the influences of the external environment takes place.

The theoretical foundation of this perspective is grounded in contemporary economic theory. In particular, within the resource-based view (J. Barney [15], B. Wernerfelt[16]) and the theory of intellectual capital (L. Edvinsson [17]), it has been demonstrated that individual abilities, knowledge, and competencies remain latent, passive "potential" until they are embedded within a specific organizational context. As noted by O. Hrishnova, it is precisely the organizational and economic mechanism of the enterprise that creates the necessary institutional environment in which human potential is synergistically combined with other assets and begins to generate added value[18]. Accordingly,

[14] Рекун І. І. Роль людського капіталу в процесі формування економічної безпеки. *Східна Європа: економіка, бізнес та управління*. 2017. Вип. 4 (09). С. 67–71.

[15] Barney J. Firm Resources and Sustained Competitive Advantage. *Journal of Management*. 1991. Vol. 17, Iss. 1. P. 99–120.

[16] Wernerfelt B. A Resource-Based View of the Firm. *Strategic Management Journal*. 1984. Vol. 5, Iss. 2. P. 171–180.

[17] Edvinsson L., Malone M. S. Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower. New York : HarperBusiness, 1997. 240 p.

[18] Грішнова О. А. Людський капітал: формування в системі освіти і професійної підготовки. Київ : Т-во «Знання», КОО, 2001. 254 с.

the enterprise acts not merely as a consumer of labor, but as an active catalyst that ensures the transformation of employees' competencies into a real economic asset.

Given the above, there is an objective need to formalize these processes in the form of an integrated structural and logical model. Such a model should clearly reflect the transition from the formation of a basic human asset (under the influence of internal and external factors) to its direct capitalization within the operational activities of the economic entity (Fig. 2). The proposed model makes it possible to distinctly differentiate between the factors that influence the individual and shape the asset, and those managerial conditions that ensure its efficient and secure utilization.

The first level of factors (the endogenous personal base) encompasses the internal characteristics of an individual, including physiological condition, abilities, motivational attitudes, and value orientations that form the primary potential for human development. This level determines an individual's capacity for learning, adaptation, and participation in economic processes.

The second level (the professional-educational framework) reflects the process of active formation and accumulation of knowledge and competencies through formal education, professional experience, and lifelong learning. It is at this level that individual potential is transformed into professional qualities suitable for economic realization.

The third level (the socio-economic environment) characterizes the external context within which human potential is realized. It includes market conditions, the institutional environment, the level of technological development, corporate practices, as well as socio-political factors that determine the opportunities and constraints for the capitalization of knowledge and skills.

This model is aimed at identifying the zones of intersection of these factors, which reflect the key stages in the transformation of human potential, where the interaction between internal personal characteristics, external conditions, and professional-educational processes takes place.

The central element of the model is the process of capitalization of human potential, which occurs at the point of integration of all three groups of factors. This indicates that human potential acquires the characteristics of capital only under conditions of alignment between the individual's internal attributes, the level of professional training, and the opportunities provided by the external environment.

It is fundamentally important that this model considers the capitalization process not in isolation, but within the framework of the economic entity's activities, which acts as the integrator of these factors. It is the enterprise that

ensures the transformation of individual potential into a factor of value creation, the formation of competitive advantages, and the provision of economic security.

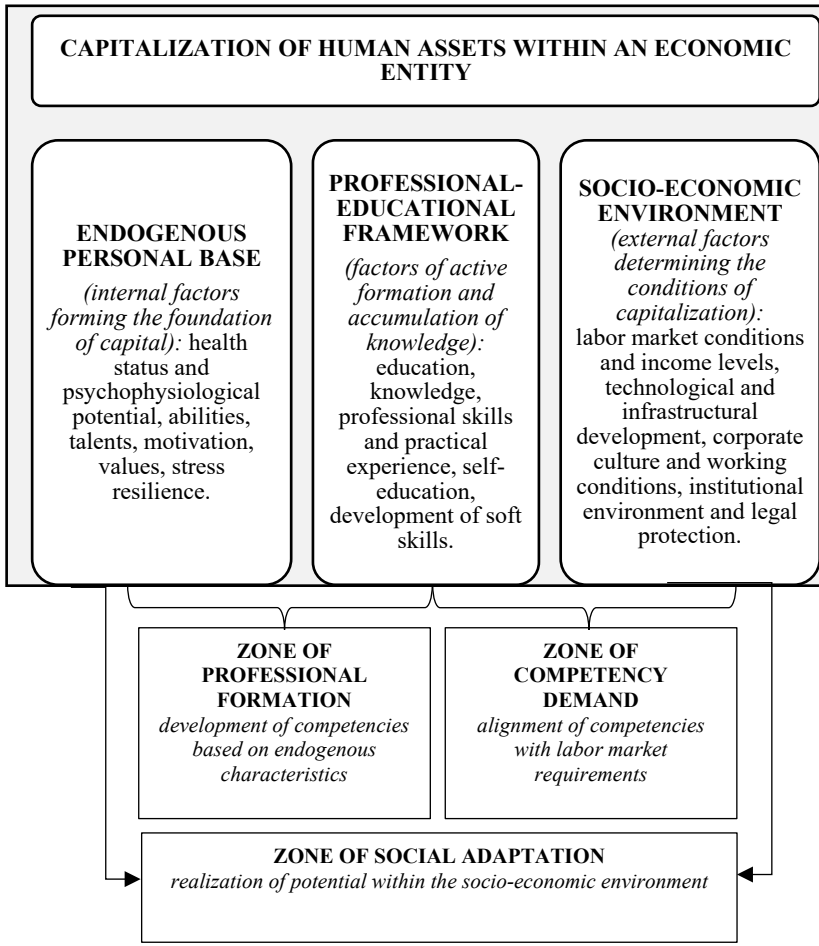

Figure 2. Model of Formation and Capitalization of Human Assets within the System of Interaction between Endogenous and Exogenous Factors

Source: developed by the author

Thus, the proposed model establishes a theoretical and methodological foundation for further expanding the analysis toward the study of the synergistic interaction between human and natural capital, which is a necessary condition for the transition to a bioeconomy model and the implementation of sustainable development principles.

At the same time, the study of human capital as an isolated factor is insufficient under contemporary ecological and economic challenges. Within the system of ensuring the economic security of an enterprise, it operates in close interaction with the material basis of production processes – natural capital, which shapes both the resource constraints and the opportunities for economic activity.

In the 1990s, the global scientific community was introduced to a conceptual model of natural capital developed by R. Costanza and H. Daly. According to this model, natural capital is viewed as stocks or assets of the natural environment that generate a continuous flow of valuable ecosystem goods and services, both in the present and in the future [19]. This approach represented a fundamental shift in economic methodology, as it was the first to legitimize nature not as a free gift, but as a capital asset that requires targeted investment for its reproduction and should be integrated into the system of macroeconomic accounting.

The institutional consolidation of this approach took place in 1992 at the United Nations Conference on Environment and Development in Rio de Janeiro. The adopted documents formulated an understanding of the term "natural capital" as the totality of physical resources and the environment as a whole, which made it possible to move beyond the paradigm of perceiving the environment exclusively as free "gifts of nature." It was also at this forum that a basic typology of natural capital was defined, including:

– non-renewable resources that are irreversibly depleted (e.g., non-renewable energy sources);

– renewable or cyclically used resources (non-energy mineral resources);

– renewable or potentially renewable resources (including soils and other environmental components that are subject to a high risk of irreversible degradation) [20].

[19] Costanza R., Daly H. Natural Capital and Sustainable Development. *Conservation Biology*. 1992. Vol. 6, no. 1. P. 37–46. DOI: https://doi.org/10.1046/j.1523-1739.1992.610037.x

[20] Декларація Ріо-де-Жанейро з навколишнього середовища і розвитку: прийнята Конференцією ООН з навколишнього середовища і розвитку, 3-14 червня 1992 р. URL: https://ips.ligazakon.net/document/MU92340

The further development and practical implementation of this concept were advanced in the works of P. Hawken, A. Lovins and L.H. Lovins [21]. In their widely recognized theory of "natural capitalism," the researchers demonstrated that traditional business models drastically underestimate the value of ecosystem services. They substantiated the objective necessity of radically increasing the productivity of natural resource use and transitioning to biologically based production models, particularly at the level of corporate governance.

The significance of this category is also emphasized in the domestic scientific discourse. In particular, V. Horiachuk notes that natural capital is a fundamental component of national wealth, and its accumulation, condition, and efficiency of use serve as a determining factor in the socio-economic growth of the state [22]. At the same time, it should be emphasized that the formation of national wealth at the macro level is impossible without the effective functioning of the micro level. Natural capital does not exist in abstraction –its actual utilization, valuation, and reproduction occur exclusively at the level of the economic entity.

Accordingly, the global ecological and economic effect, as well as the sustainable growth of the state, is directly influenced by how rationally individual enterprises integrate natural resources into their operational activities and how effectively they synergistically combine them with the intellectual potential (human capital) of their employees.

Moreover, the ability of an enterprise not only to consume natural capital extensively but also to preserve and reproduce it critically depends on the qualitative characteristics of its human capital – namely, the level of environmental awareness of personnel, the possession of innovative competencies, and so-called "green skills". Thus, the macroeconomic category of natural capital requires its mandatory implementation at the micro level. This, in turn, unequivocally underscores the relevance of the proposed subject-based approach and necessitates the development of appropriate applied tools within the enterprise's management accounting system.

In this context, particular attention should be paid to the approach proposed by I. Balaniuk and A. Zabara, who, within the framework of the relationship between sustainable development and the bioeconomy, consider the effective management of an asset portfolio – comprising human and natural capital, as

[21] Hawken P., Lovins A., Lovins L. H. Natural Capitalism: Creating the Next Industrial Revolution. Boston : Little, Brown and Company, 1999. 396 p.

[22] Горячук В. Ф. Природний капітал як економічна категорія. *Економічні інновації*. 2012. Вип. 48. С. 88-93. URL: http://jnas.nbuv.gov.ua/article/UJRN-0001184599

interrelated components of the overall economic potential, thereby confirming their objectively determined interdependent nature [23].

At the international level, this thesis finds empirical confirmation in studies conducted by a group of authors led by M. Radulescu, which demonstrate that the interaction between human and natural capital generates a synergistic effect in achieving sustainable development goals. They emphasize that only under conditions of a sufficient level of education, technological skills, and the efficient use of natural resources is it possible to ensure long-term ecological and social balance [24]. Such an approach reflects the systemic nature of sustainable development, in which human and natural capital mutually reinforce each other, forming the foundation for innovative development.

At the same time, understanding the mechanisms of this synergy is impossible without recognizing the evolutionary nature of capital. In scientific research, considerable attention is paid to the influence of systemic transformations of the economy on the processes of their formation. In particular, in the work of D. Melnychuk, it is substantiated that the key determinants of human capital development are technological, managerial, and financial transformations occurring within the broader socio-economic development [25].

The stages of technological development lead to a rapid increase in the requirements for the level of employees' qualifications; managerial transformations contribute to a shift in the perception of employees as the primary carriers of value, while financial evolution ensures expanded access to funding sources and the development of labor market infrastructure. The combined impact of these processes stimulates investment in education and professional training and enhances the mobility of labor resources.

However, within the context of this study, it should be emphasized that only through integration into the processes of the economic entity do these newly acquired knowledge and skills create the preconditions for the final transformation of human potential into a form of capital capable of consciously and effectively managing natural assets.

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[23] Баланюк І., Забара А. Роль біоекономіки у створенні можливостей для сталого розвитку. економічний дискурс. *Міжнародний науковий журнал*.2017.Випуск 1. С. 58–62.

[24]The Impact of Human Capital, Natural Resources, and Renewable Energy on Achieving Sustainable Cities and Communities in European Union Countries / M. Radulescu et al. *Sustainability*. 2025. Vol. 17, no. 5. P. 2237. URL: https://doi.org/10.3390/su17052237

[25] Мельничук Д. П. Людський капітал: пріоритети модернізації суспільства у контексті поліпшення якості життя населення : монографія. Житомир : Полісся, 2015. 564 с.

The genesis of understanding the synergistic interaction between human and natural capital is not static; it reflects the long-term evolution of economic thought and shifts in technological paradigms. To trace the transformation of approaches to the integration of these types of capital, it is advisable to conduct a retrospective analysis across key industrial cycles. The proposed typology clearly demonstrates the gradual transition from extensive resource consumption to the intellectual reproduction of resources (Fig. 3).

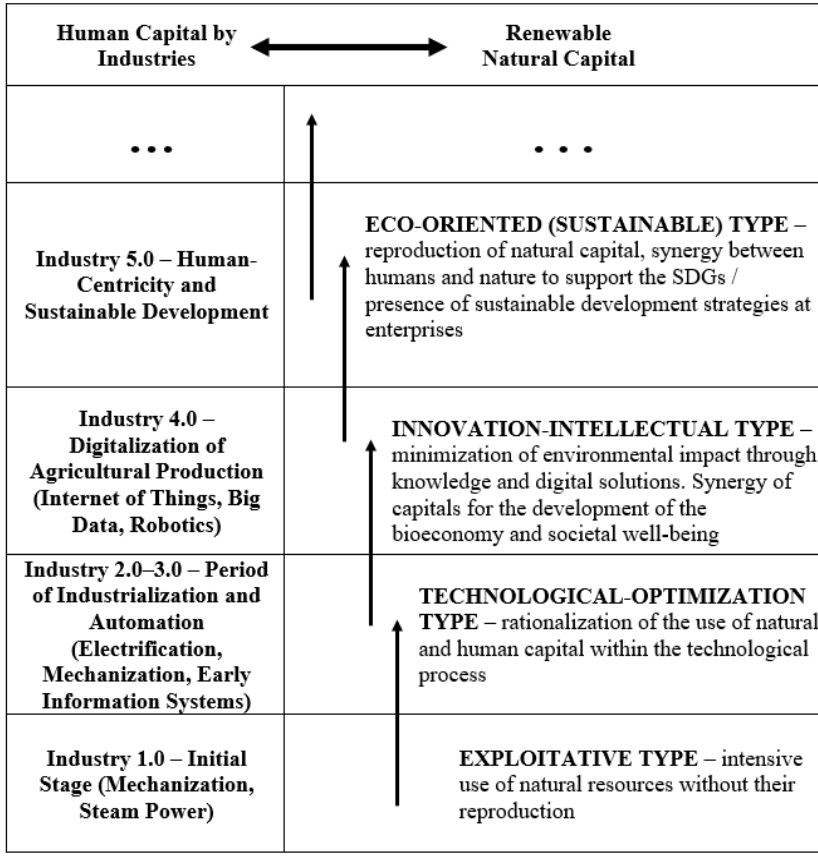

Figure 3. Typology of interaction between human and renewable natural capital in the history of industrial cycles

Source: compiled by the author

The analysis of the presented typology makes it possible to distinguish four consecutive types of capital interaction:

– exploitative type (Industry 1.0) – at the initial stage of the industrial revolution, characterized by early mechanization and the introduction of steam power, a purely extractive approach prevailed. Human capital was used primarily as physical labor for the intensive extraction of natural resources without any consideration of the possibilities or necessity of their reproduction;

– technological-optimization type (Industry 2.0–3.0) – with the transition to the period of industrialization and automation (the development of electrification, advanced mechanization, and the emergence of early information systems), a process of rationalization began. The initial optimization of both human and natural capital within technological processes took place; however, environmental imperatives still remained secondary to economic efficiency;

– innovation-intellectual type (Industry 4.0) – a qualitative leap occurs in the era of total digitalization (particularly in agricultural production and other resource-intensive sectors). The implementation of the Internet of Things (IoT), Big Data technologies, and robotics fundamentally transforms the role of humans. Human intellect generates digital solutions to minimize environmental impact. It is at this stage that a purposeful synergy of capitals emerges, serving as a driver for the development of the bioeconomy and the enhancement of overall societal well-being;

– eco-oriented (sustainable) type (Industry 5.0) – the contemporary stage represents the highest level of evolution, the fundamental principles of which are human-centricity and sustainable development. A conceptual shift occurs from merely reducing environmental harm to the proactive reproduction of natural capital. The synergistic interaction between humans and nature becomes an indispensable instrument for achieving the global Sustainable Development Goals. At the microeconomic level, this is formalized through the development, adoption, and implementation of corporate sustainable development strategies.

In this context, it is appropriate to consider the enterprise as the basic subject of institutional interaction, within which the transformation of resources into capital and the creation of added value take place. Such an approach provides a methodological foundation for further research into the subject-based nature of the enterprise and substantiates the role of management accounting as an instrument for informational support of the interaction between human and natural capital within the system of enterprise economic security.

Traditional economic approaches have long viewed the enterprise primarily as a passive consumer of external factors of production. However, under

conditions of contemporary transformations, there is an objective need to shift this perspective and introduce the concept of "subject-based baseline." This approach defines the enterprise as a central node – a basic subject of institutional interaction – at the level of which abstract macroeconomic processes acquire real material and value-based embodiment.

The scientific foundation of this perspective is grounded in the evolution of the theory of the firm and sustainable development concepts. While the neoclassical school considered the enterprise as a mechanism for the mechanical transformation of input resources into finished products with the aim of profit maximization, modern institutional theory and stakeholder theory demonstrate otherwise. The enterprise is a complex network of institutional relationships, capable of proactively shaping its ecological and economic environment [26].

In the context of the transition to Industry 5.0 and the bioeconomy paradigm, this proactivity of the economic entity becomes critically important. As noted by leading researchers in the field of corporate sustainability and environmental accounting, in particular S. Schaltegger and R. Burritt, global macroeconomic sustainable development goals remain purely declarative until they are operationalized at the micro level [27].

For this proactivity to acquire a manageable and measurable character, it is necessary to recognize that the enterprise functions not merely as a locus of resource combination, but as a baseline entity within the entire system of capitalization. It is precisely at this micro level that the primary identification, assessment, and direction of the synergistic interaction between human and natural assets take place.

This transformation of value unfolds through different stages depending on the dominant business strategy. It may be oriented toward the simple growth of technological production, as was characteristic of the exploitative type of interaction (the Industry 1.0–3.0 paradigm), or toward supporting sustainable development strategies, which constitute an imperative for the eco-oriented type (the Industry 4.0–5.0 paradigm). Each type of strategy requires its own unique set of human competencies – from professional skills and experience to innovative bioeconomic and sustainability-oriented knowledge.

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[26] Freeman R. E. Strategic Management: A Stakeholder Approach. Cambridge : Cambridge University Press, 2010. 292 p.

[27] Schaltegger S., Burritt R. L. Sustainability accounting for companies: Catchphrase or decision support for business leaders? *Journal of World Business*. 2010. Vol. 45, Iss. 4. P. 375–384.

Accordingly, for the effective management of these processes, they must be reflected within the enterprise's accounting system. Traditional accounting should evolve into a system that records not only financial flows but also changes in the value of natural and human assets, thereby forming "environmental and human capital accounting" at the micro level. Subsequently, these micro-level data become the basis for aggregation. They feed into the System of National Accounts, expanding the scope of capital objects at the national level and enabling the transition from individual enterprise assets to national wealth expressed in the form of human and renewable natural capital.

The entirety of these processes – from enterprise-level strategy to national accounting – forms an integrated theoretical concept, which we present in the form of a schematic model (Fig. 4).

Within the proposed approach, the enterprise is viewed not merely as a transactional node, but as a complex intellectual and ecological space in which new forms of value are generated. The transition from traditional agriculture to bioeconomy- and sustainability-oriented systems has been accompanied by a gradual transformation in the role of human and natural capital – from factors of production to enterprise assets whose value increases as a result of the synergistic interaction between professional, innovation-technological, and bioeconomic competencies of personnel and renewable natural assets (soil, biotic, water, energy, atmospheric, and ecosystem resources).

The proposed theoretical concept of the subject-based baseline of economic entities creates methodological preconditions for updating approaches to the representation of human and natural capital within the System of National Accounts, as well as for shaping new strategic priorities for their use in state, national, and sectoral sustainable development programs.

Such a methodological transformation requires moving away from a narrow understanding of profit toward the concept of "Total Value," which incorporates environmental and social externalities. The implementation of the subject-based approach makes it possible to overcome the existing gap between microeconomic data of enterprises and macroeconomic indicators of national wealth. In this context, particular importance is attached to the development of the System of Environmental-Economic Accounting, which is integrated with the traditional national accounts system and requires a relevant informational base formed directly at the level of economic entities.

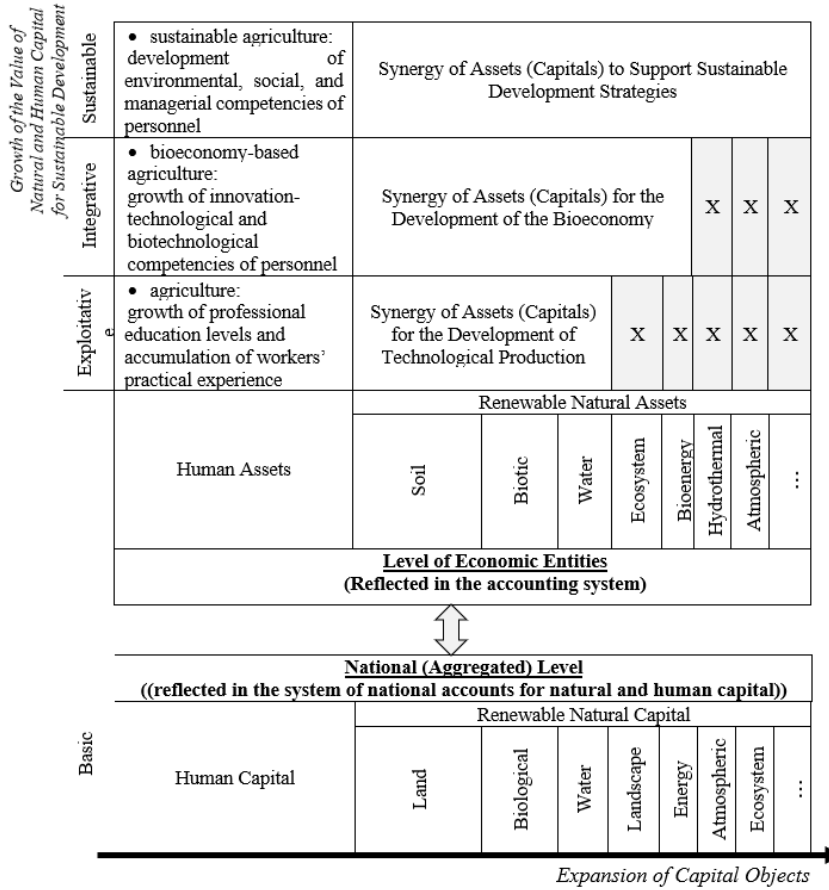

Figure 4. Theoretical Concept of the Baseline Role of Economic Entities in the Synergistic Growth of the Value of Human and Natural Capital under Conditions of Technological and Sustainable Development

Source: *compiled by the author*

At the same time, the linkage between the operational activities of individual enterprises and national sustainable development indicators should be ensured through the mechanism of management accounting, which is being transformed into a system of integrated reporting. This makes it possible not only to capitalize intangible and natural assets on enterprise balance sheets, but

also to provide the state with reliable data on the actual condition and dynamics of the reproduction of national wealth. Accordingly, the subject-based baseline of the enterprise becomes the foundation for the preventive management of environmental risks and for ensuring long-term economic security both at the level of individual businesses and at the level of the national economy as a whole.

Managerial decisions at the level of the baseline economic entity determine the mechanism for integrating human and natural capital into value creation processes and the formation of economic security. In this context, there is an objective need to transform management accounting from a tool of retrospective recording of business transactions into an integrated information and analytical system capable of reflecting both financial and non-financial aspects of enterprise activity. Such an approach involves incorporating into the accounting system indicators that characterize the condition, dynamics, and efficiency of the use of human and natural capital, as well as the results of their interaction.

A key role in this process is played by the implementation of non-financial indicators, in particular ESG metrics, which make it possible to assess the environmental, social, and governance aspects of enterprise activity. It is through such indicators that both quantitative and qualitative representation of the interdependence between human potential, natural resources, and managerial practices becomes possible.

The further development of these approaches is reflected in the concept of integrated reporting, which ensures the consolidation of financial and non-financial information into a single system oriented toward disclosing value creation processes in the short, medium, and long term. Within such a system, management accounting serves as a key instrument for forming the analytical basis for decision-making aimed at the balanced use and reproduction of human and natural capital.

An important direction in the development of management accounting is also the application of analytical models that allow for the assessment of the synergy effect of capitals, in particular through identifying the relationship between the level of human capital development, the efficiency of natural resource utilization, and indicators of enterprise economic security. Such models enable a transition from the recording of individual indicators to a comprehensive evaluation of value creation processes.

Thus, under modern conditions, management accounting is transforming into a system-forming element that ensures not only the informational representation of enterprise activities but also the integration of various forms

of capital into a unified analytical system. This, in turn, creates the methodological foundation for the implementation of the concept of subject-based baseline and enables the representation of the synergistic interaction between human and natural capital as a key factor in ensuring enterprise economic security.

The synergistic interaction between human and natural capital within the activities of an economic entity forms a qualitatively new level of ensuring enterprise economic security. Unlike the isolated use of individual types of capital, their integrated application makes it possible to achieve an effect that exceeds the sum of the results of their autonomous functioning, thereby exerting a comprehensive impact on economic, environmental, and social performance.

In particular, the combination of a high level of human capital development with the rational use of natural resources contributes to reducing risks associated with resource constraints, environmental threats, technological uncertainty, and managerial errors. The systematic incorporation of environmental factors into managerial decision-making processes makes it possible to minimize the negative consequences of economic activity and to enhance resource efficiency.

At the same time, such interaction ensures an increase in enterprise resilience through the diversification of value creation sources, the reduction of dependence on individual types of resources, and the formation of the capacity to reproduce both human and natural capital. In this context, resilience acquires a systemic character, encompassing not only financial results but also the environmental and social dimensions of enterprise functioning.

Moreover, the synergy of these capitals serves as a determining factor in ensuring the enterprise's adaptability to dynamic changes in the external environment. The ability to integrate human intellect, innovative technologies, and natural resources into a flexible management system enables the enterprise to respond promptly to market, institutional, and environmental challenges, thereby creating the preconditions for long-term development.

It is important to emphasize that the realization of the synergistic effect of human and natural capital is possible only under conditions of their proper informational representation within the management accounting system. It is management accounting that acts as the instrument ensuring the integration of financial and non-financial indicators, forming the analytical basis for evaluating the efficiency of capital utilization, and enabling the identification of interrelationships between them. In this context, particular importance is attached to the implementation of ESG indicators, the development of

integrated reporting, and the application of analytical models focused on assessing long-term value.

Thus, the synergistic interaction between human and natural capital acquires the status of a system-forming factor in ensuring enterprise economic security, as it simultaneously reduces risks and enhances the resilience and adaptability of its functioning. In turn, this necessitates the further development of capital theory through the lens of the subject-based baseline, according to which the enterprise acts as the integrator of the processes of formation, transformation, and capitalization of human and natural potential under contemporary conditions of sustainable development.

CONCLUSIONS

The conducted research has established that the formation of enterprise economic security under modern conditions is determined by a complex and multi-level system of the institutional environment, which encompasses a set of formal and informal institutions and organizations regulating the economic behavior of economic entities. Within this environment, management accounting is transforming from a traditional tool for cost recording into a proactive information and analytical system capable of ensuring enterprise adaptation to uncertainty, risk identification, and support for strategic management.

At the same time, it has been determined that institutional determinants influence not only the organization of accounting processes but also the substantive content of accounting objects, which necessitates the expansion of their scope. In this context, the inclusion of human and natural capital in the management accounting system as key carriers of value, sources of risk, and factors of long-term enterprise development becomes particularly important.

Further development of the study has shown that modern approaches to the interpretation of capital, based on its resource-factor understanding, are insufficient to explain value creation processes under conditions of sustainable development. It is substantiated that human and natural capital do not function in isolation but in interaction, forming a synergistic effect manifested in risk reduction, increased resilience, and enhanced adaptability of the enterprise to changes in the external environment.

The key result of the research is the advancement of capital theory through the introduction of the concept of the subject-based baseline, according to which economic entities act as the determining factor in the processes of formation, transformation, and value growth of human and natural capital. It is

proven that within the enterprise, their synergistic utilization as assets participating in value creation and ensuring economic security takes place.

It has been established that under the transition from a traditional economic model to a bioeconomy and sustainable development paradigm (Industry 4.0–5.0), the enterprise acquires the status of a central integrator of capitalization processes, ensuring the combination of human potential, natural resources, and managerial decisions into a unified value creation system.

This theoretical contribution makes it possible to enrich the policy of representing human and natural capital within the System of National Accounts, substantiate strategic directions for their use in state, national, and sectoral programs, and develop new approaches to designing enterprise development strategies and accounting policies under sustainable management conditions.

In summary, it has been established that management accounting under modern conditions performs a system-forming role in ensuring enterprise economic security, as it is through it that the integration of financial and non-financial information occurs, the synergistic interaction of human and natural capital is reflected, and the analytical basis for effective managerial decision-making is formed.

SUMMARY

This section examines the theoretical, methodological, and institutional foundations of the development of management accounting within the system of ensuring enterprise economic security. It is substantiated that the institutional environment determines not only the organization of accounting processes but also the approaches to the identification of accounting objects. The transformation of management accounting into a proactive information and analytical system oriented toward supporting strategic managerial decision-making is demonstrated.

The necessity of expanding accounting objects through the inclusion of human and natural capital as key carriers of value is established. It is shown that modern approaches to capital interpretation require reconsideration under conditions of sustainable development. The synergistic nature of the interaction between human and natural capital in value creation processes is substantiated. It is determined that such interaction contributes to risk reduction, increased resilience, and enhanced adaptability of the enterprise.

The theory of capital is further developed through the introduction of the concept of the subject-based baseline of the enterprise as an integrator of capitalization processes. It is proven that it is at the enterprise level that the

transformation of potential into capital occurs within the framework of Industry 4.0–5.0.

The necessity of transforming management accounting into a system of integrated representation of financial and non-financial indicators in the context of sustainable development is substantiated.

References

1. Пищуліна О., Юрочко Т., Міщенко М., Жаліло Я. Розвиток людського капіталу: на шляху до якісних реформ. Київ : Центр Разумкова. Вид. «Заповіт». 2018. 367 с. URL: https://razumkov.org.ua/uploads/article/2018_LUD_KAPITAL.pdf
2. Barbier E. B. The concept of natural capital. *Oxford Review of Economic Policy.* 2019. Vol. 35, no. 1. P. 14–36. DOI: https://doi.org/10.1093/oxrep/gry028
3. North D.C. Institutions, institutional change, and economic performance. Cambridge: Cambridge University Press, 1990. 152 p.
4. Veblen T. The Theory of the Leisure Class: An Economic Study of Institutions. New York : B. W. Huebsch, 1918. 184 p.
5. Жук В.М. Концепція розвитку бухгалтерського обліку в аграрному секторі економіки: монографія. Київ: ННЦ «Інститут аграрної економіки» УААН, 2009. 648 с.
6. Василішин С. І. Обліково-аналітичне забезпечення в системі ризиків та загроз економічної безпеки аграрних підприємств України: монографія. Харків. нац. аграр. ун-т ім. В.В. Докучаєва. Харків: ТОВ «Друкарня Мадрид», 2020. 419 с.
7. Петрук О.М., Василішин С.І. Інституціональні фактори обліково-аналітичного забезпечення управління економічною безпекою підприємств. *Проблеми теорії та методології бухгалтерського обліку, контролю і аналізу*. 2021. № 3(47). Р. 47–55.
8. Ружицький І. Інституційне регулювання економічної безпеки україни: теорія, методологія, практика : автореф. дис. … д-ра екон. наук : 08.00.03. Львів, 2021. 41 с.
9. Багрій К., Вдовічен А., Шеверя Я. (2025). Розвиток управлінського обліку в контексті Індустрії 4.0. *Актуальні питання економічних наук*. 2025. Вип. 17. DOI: https://doi.org/10.5281/zenodo.17758081
10. Becker, Gary S. Human Capital: A Theoretical and Empirical Analysis. Third Edition. The University of Chicago Press, 1993. 380 p. URL: http://digamo.free.fr/becker1993.pdf

11. Лібанова Е.М., Макарова О.В., Саріогло В.Г. Політика активізації як інвестиція у людський капітал: теорія і практика. *Наука та інновації*. 2020. Т. 16, № 5. С. 57–68. DOI: https://doi.org/10.15407/scin16.05.057

12. World Bank. Human Capital Project / Human Capital Index. URL: https://www.worldbank.org/en/publication/human-capital

13. Пронько Л. Організаційно-економічний механізм відтворення людського капіталу сільських територій: дис. … д-ра екон. наук : 08.00.03. Вінниця, 2026. 729 с.

14. Рекун І. І. Роль людського капіталу в процесі формування економічної безпеки. *Східна Європа: економіка, бізнес та управління*. 2017. Вип. 4 (09). С. 67–71.

15. Barney J. Firm Resources and Sustained Competitive Advantage. *Journal of Management*. 1991. Vol. 17, Is. 1. P. 99–120.

16. Wernerfelt B. A Resource-Based View of the Firm. *Strategic Management Journal.* 1984. Vol. 5, Is. 2. P. 171–180.

17. Edvinsson L., Malone M. S. Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower. New York: HarperBusiness, 1997. 240 p.

18. Грішнова О. А. Людський капітал: формування в системі освіти і професійної підготовки. Київ : Т-во «Знання», КОО, 2001. 254 с.

19. Costanza R., Daly H. Natural Capital and Sustainable Development. *Conservation Biology*. 1992. Vol. 6, no. 1. P. 37–46. DOI: https://doi.org/10.1046/j.1523-1739.1992.610037.x

20. Декларація Ріо-де-Жанейро з навколишнього середовища і розвитку: прийнята Конференцією ООН з навколишнього середовища і розвитку, 3-14 червня 1992 р. URL: https://ips.ligazakon.net/document/MU92340

21. Hawken P., Lovins A., Lovins L. H. Natural Capitalism: Creating the Next Industrial Revolution. Boston : Little, Brown and Company, 1999. 396 p.

22. Горячук В. Ф. Природний капітал як економічна категорія. *Економічні інновації*. 2012. Вип. 48. С. 88–93. URL: http://jnas.nbuv.gov.ua/article/UJRN-0001184599

23. Баланюк І., Забара А. Роль біоекономіки у створенні можливостей для сталого розвитку. економічний дискурс. *Міжнародний науковий журнал*. 2017. Вип. 1. С. 58–62.

24. The Impact of Human Capital, Natural Resources, and Renewable Energy on Achieving Sustainable Cities and Communities in European Union Countries / M. Radulescu et al. *Sustainability*. 2025. Vol. 17, no. 5. P. 2237. DOI: https://doi.org/10.3390/su17052237

25. Мельничук Д. П. Людський капітал: пріоритети модернізації суспільства у контексті поліпшення якості життя населення: монографія. Житомир : Полісся, 2015. 564 с.

26. Freeman R. E. Strategic Management: A Stakeholder Approach. Cambridge: Cambridge University Press, 2010. 292 p.

27. Schaltegger S., Burritt R. L. Sustainability accounting for companies: Catchphrase or decision support for business leaders? *Journal of World Business*. 2010. Vol. 45, Iss. 4. P. 375–384.

28. Serpeninova Yu., Partila P., Raboshuk A., Krukhmal O., Nezhyd Yu. Transparency in Human Capital Disclosure in Non-Financial Reporting: Towards Ethical Governance and Corporate Social Responsibility in Banking. *Business Ethics and Leadership.* 2025. Vol. 9 (2). P. 120–129. DOI: https://doi.org/10.61093/bel.9(2).120-129.2025

29. Жук В.М., Бездушна Ю.С., Василішин С.І., Нежид Ю.С., Волошина О.В. Теоретико-прикладні основи моделювання аграрного устрою і державної аграрної політики. *Економіка України*. 2024. № 11. С. 46-73. DOI: https://doi.org/10.15407/economyukr.2024.11.045

Information about the author:
Yuliia Nezhyd
PhD in Management,
Senior Researcher at the Accounting and Taxation Department,
NSC “Institute of Agrarian Economics”;
Academic Secretary,
Institute Accounting and Finance of the NAAS
10 Heroiv Oborony Str., Kyiv, 03127, Ukraine