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SUSTAINABLE BUSINESS MODELS OF WASTE MANAGEMENT AS A TOOL FOR ACHIEVING CLIMATE NEUTRALITY*

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СТАЛІ БІЗНЕС-МОДЕЛІ УПРАВЛІННЯ ВІДХОДАМИ ЯК ІНСТРУМЕНТ ДОСЯГНЕННЯ КЛІМАТИЧНОЇ НЕЙТРАЛЬНОСТІ

Formulation of the problem. The increasing generation of waste, depletion of natural resources, and adverse environmental impacts of the linear “take–make–dispose” model have intensified the need for a transition towards circular and climate-neutral development. Waste management is no longer regarded solely as an environmental protection activity; it is increasingly becoming a source of secondary raw materials, innovation, entrepreneurial opportunities, and sustainable value creation. In this context, both start-ups and established enterprises can play an important role in introducing resource-efficient

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technologies, developing circular products and services, and implementing new approaches to waste prevention, reuse, repair, recycling, and recovery.

EU waste-management targets are among the key drivers of increasing recycling rates and accelerating the transition towards a circular economy: the Waste Electrical and Electronic Equipment (WEEE) Directive sets targets for the separate collection and recycling of electrical and electronic waste [1]; the Waste Framework Directive includes targets for the recycling and preparing for reuse of municipal waste [2; 3]; the Packaging and Packaging Waste Regulation defines targets for recycling packaging waste. In total, EU waste legislation includes more than 30 binding targets for the period of 2015–2030.

Compliance with these requirements requires not only technological modernisation but also the transformation of existing business models and the development of new mechanisms for creating, delivering, and capturing sustainable value. However, start-ups and established enterprises face various barriers to this transformation, including limited financial resources, insufficient knowledge and competencies, difficulties in selecting appropriate circular solutions, organisational resistance to change, and weak cooperation with research institutions, public authorities, investors, civil society organisations, and other businesses. Therefore, it is important to systematise sustainable business-model archetypes and determine how they can be applied and combined by both newly established and operating enterprises to enhance resource efficiency, waste valorisation, social inclusion, collaborative innovation, and the scaling up of circular and climate-neutral solutions.

Analysis of recent research and publications. The theoretical foundations for the study of innovation and entrepreneurial development were laid by J. Schumpeter [4]. The relationship between innovation, competitiveness, and global sustainability have been studied by S. Hart and M. Milstein [5], while the development of sustainable ventures have been researched by P. Muñoz and D. Dimov [6]. The conceptual foundations of business models have been considered by J. Richardson [7], A. Osterwalder, Y. Pigneur and C. Tucci [8]. Business models for sustainable innovation have been researched by F. Boons [9] and F. Lüdeke-Freund [10], N. Bocken, S. Short, P. Rana, and S. Evans [11] proposed a classification of sustainable business model archetypes, grouping them into technological, social, and organisational categories. The systemic nature of sustainable business models have been examined by N. Abdelkafi and K. Täuscher [12], while the role of stakeholders in sustainable value creation has been studied by B. Freudenreich and S. Schaltegger [10], M. Pieroni, T. McAloone, and D. Pigosso [13] systematised approaches to business model transformation in accordance with circular economy principles. The implementation of sustainable business models in start-ups has been researched by A. Nunes, S. Morioka, and I. Bolis [14].

At the same time, the integrated application of sustainable business model archetypes by start-ups and established enterprises remains insufficiently examined, particularly with regard to inclusive value creation and collaborative ecosystems. The role of education, cross-sectoral cooperation, and youth competence development in implementing circular and climate-neutral business models also requires further substantiation.

Setting objectives. The purpose of the article is to examine the theoretical foundations of formation of sustainable business models, systematise their key archetypes, and identify opportunities for their application and combination by start-ups and established enterprises to improve waste management and create economic, environmental, and social value, and achieve climate neutrality.

Presentation of the main research material. Waste management is one of the key components of the transition to a circular economy and the achievement of climate neutrality. The introduction of mandatory targets in the European Union has contributed to an increase in waste recycling and a gradual shift from waste disposal towards its reuse as secondary raw materials. However, progress has stagnated recently and in some cases reversed, with total waste recycling rates lower in 2022 than a decade earlier (Fig. 1).

The majority of waste was still disposed of through incineration or landfilling. Recycling rates of municipal and packaging waste as well as e-waste (which also represent significant sources of critical raw materials) had been slowly increasing until recently, indicating a move towards a more circular economy. The overall recycling rate, i.e. the ratio between total waste generated excluding major mineral wastes and the quantities that were managed through recycling, was at 44.3 % in 2022. The highest recycling rate in 2023 was registered for packaging (67.5 %) followed by municipal (47.7 %) and e-waste (30.8 %) [15]. Until recently, the progress made for these three key waste streams has been more significant than in overall recycling. This reflects the importance of the strong EU policies driving improvements in waste management. However, in recent years, the recycling rates for all three waste streams have been stagnating and the overall recycling rate has decreased since 2018 and remains below 50 %. This means the majority of generated waste is disposed of in landfills and incineration plants.

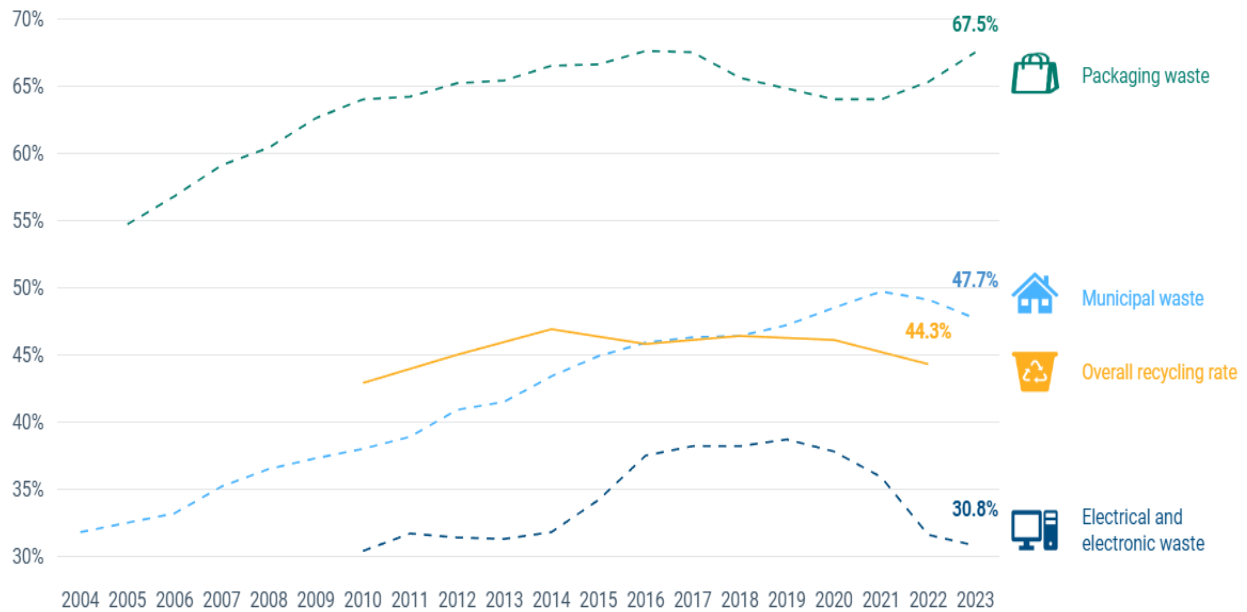
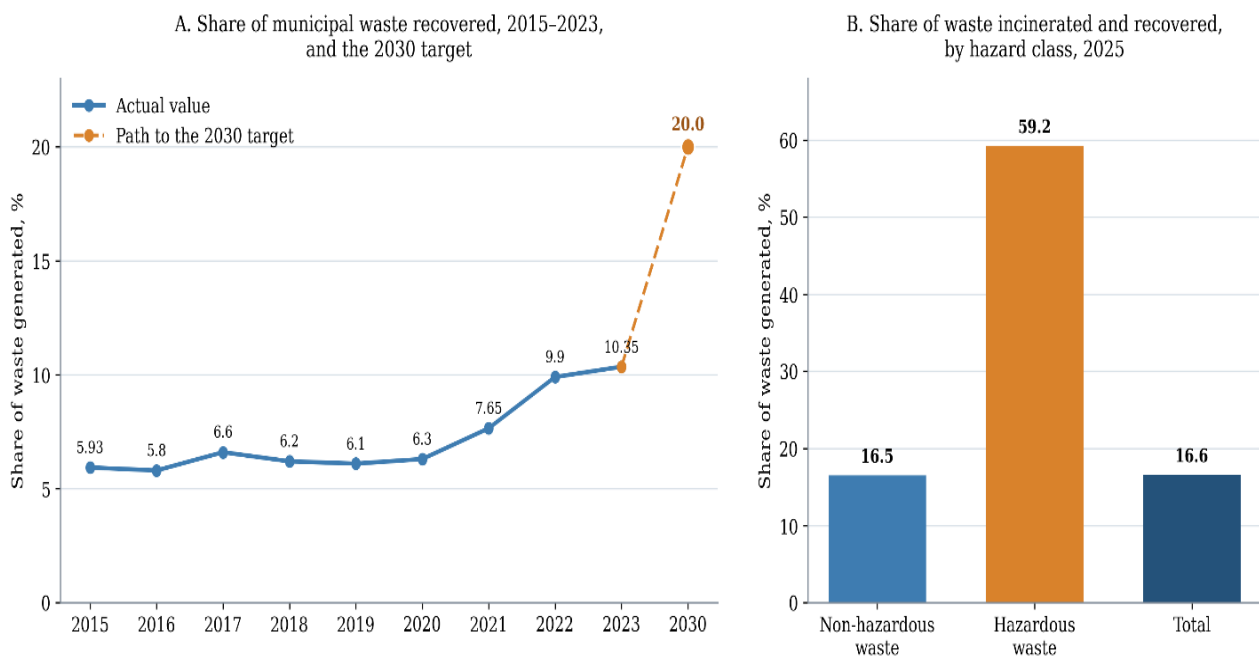


Fig. 1. Recycling rates in Europe by waste stream

Source: [15]

In 2023, Ukraine generated 4.9 million tonnes of municipal waste, including 218,000 tonnes of plastic, glass, and waste paper, according to the State Statistics Service of Ukraine. Although the share of recovered municipal waste increased from 5.93 % in 2015 to 10.35 % in 2023, the overall recycling rate remains low, ranging between 4 % and 8 %, compared with over 90 % in some EU countries [16]. Consequently, most municipal waste remains outside recycling processes, with landfilling continuing to be the dominant waste management method. To achieve the national target of recovering 20 % of municipal waste by 2030, the 2023 level must almost double. Furthermore, in 2025, the share of incinerated and recovered waste varied considerably by hazard category, reaching 59.2 % for hazardous waste compared with 16.5 % for non-hazardous waste (Fig. 2). This waste management structure leads to the loss of valuable secondary raw materials, increases environmental pressures, and hampers progress towards climate neutrality.



Note: the panels present indicators with different scopes and are not directly comparable.

Fig.2. Trends and Structural Indicators of Waste Recovery in Ukraine

Source: developed by the authors from [17; 18]

The persistently low level of waste recycling in Ukraine should be considered in the broader context of national resource efficiency. The transition towards climate neutrality requires not only increasing waste recovery but also reducing the consumption of energy, materials and water, as well as waste generation and greenhouse gas emissions per unit of economic output. The dynamics of Ukraine's GDP resource intensity relative to the 2015 baseline are presented in Table 1.

Table 1

Resource Intensity of Gross Domestic Product (the Ratio of Physical Volumes of Natural Resources Consumed, Waste Generated and Pollutant Emissions to Gross Domestic Product) Compared with 2015, %

Indicator	2015	2016	2017	2018	2019	2020	2021 ²	2022 ²	2023 ²	2024 ²
Energy intensity of GDP	100,0	102,3	94,7	95,2	88,5	88,9	– 1	– 1	– 1	– 1
Material intensity of GDP	100,0	100,0	98,2	97,2	100,4	99,9	108,2	57,6	40,4	47,5
Carbon intensity of GDP	100,0	105,8	85,1	83,8	77,9	72,8	72,2	57,4	58,1	51,2
Water intensity of GDP	100,0	98,2	91,7	95,1	91,6	94,2	77,3	60,1	59,9	48,0
Waste intensity of GDP	100,0	92,5	111,6	103,9	126,1	137,3	141,6	82,1	67,4	88,2

¹ The indicator calculation will resume once the input data have been published. Their publication will be gradually restored following the entry into force of the amendment to paragraph 1 of the Law of Ukraine "On the Protection of the Interests of Reporting Entities and Other Document Submitters during Martial Law or a State of War", concerning the resumption of statistical and financial reporting.

² According to the information provided in the statistical products of the State Statistics Service of Ukraine, the input data used for the calculation may be revised.

Source: [19]

The data indicate an overall reduction in most components of Ukraine's GDP resource intensity compared with 2015. The most substantial improvements were recorded in material, carbon and water intensity. In 2024, these indicators stood at 47.5 %, 51.2 % and 48.0 % of their respective 2015 levels.

However, waste intensity followed a less stable trajectory: after increasing to 141.6 % in 2021, it declined to 67.4 % in 2023 but rose again to 88.2 % in 2024. This volatility indicates that waste generation has not yet been sustainably decoupled from economic activity. Moreover, the sharp reductions observed after 2021 should be interpreted cautiously, as they may reflect wartime disruptions, changes in production volumes and limitations in statistical coverage rather than exclusively structural improvements in resource efficiency. Therefore, strengthening sustainable waste management business models remains essential for converting waste into secondary resources, reducing GDP waste intensity and supporting Ukraine's transition towards climate neutrality.

The trends outlined above highlight the need to transform approaches to entrepreneurial activity and reconsider the role of business in addressing environmental and social challenges. Traditionally, entrepreneurship was primarily focused on creating financial value [4]. However, growing awareness of global environmental challenges, including climate change, natural resource depletion, and waste accumulation, has led to the gradual integration of social and environmental objectives into core business activities. S. Hart and M. Milstein were among the first to substantiate the relationship between entrepreneurship and sustainable development, viewing sustainability as a source of new opportunities for entrepreneurs and innovators [5]. Under current conditions, businesses are increasingly seeking to minimise their negative environmental impact and integrate social and environmental values into the processes of value creation, delivery, and capture [6].

Sustainable development involves meeting the needs of present society without compromising the ability of future generations to meet their own needs. Accordingly, sustainable entrepreneurship encompasses activities aimed not only at generating profit but also at achieving environmental, social, and governance objectives. This approach facilitates the creation of integrated value for a broad range of stakeholders and contributes to the efficient use of resources and the reduction of waste and greenhouse gas emissions.

Start-ups play a particularly important role in promoting these approaches, as their flexibility and innovative capacity enable them to implement sustainable business models more rapidly. The application of such models is becoming an important source of competitive advantage, long-term sustainability, and business adaptability. A business model defines how an enterprise creates, delivers, and captures value, encompassing the development of a value proposition, product or service design, pricing, cost and revenue structures, and interaction with partners and consumers. The uniqueness of a business model is shaped by integrating the enterprise's internal value chain with those of other participants in the relevant value network.

In the field of waste management, sustainable business models involve a transition from the linear "take–make–use–dispose" principle to circular approaches to value creation. Within such models, waste is regarded as a potential secondary resource, while waste prevention, reuse, repair, recycling, and material

recovery are integrated into core business processes. This makes it possible to reduce the resource intensity of production, minimise environmental pressures, create new revenue streams, and contribute to achieving climate neutrality.

A business model is a conceptual framework that defines the logic through which an organisation creates, delivers, and captures value [14]. To provide a more comprehensive representation of a sustainable business model, its structure should encompass not only value proposition, value creation and delivery, and value capture, but also the external drivers of business model development and the resulting economic, environmental, and social impacts. In the case of waste management start-ups, particular emphasis should be placed on circular resource flows, stakeholder collaboration, technological innovation, and contribution to climate neutrality (Fig. 3).

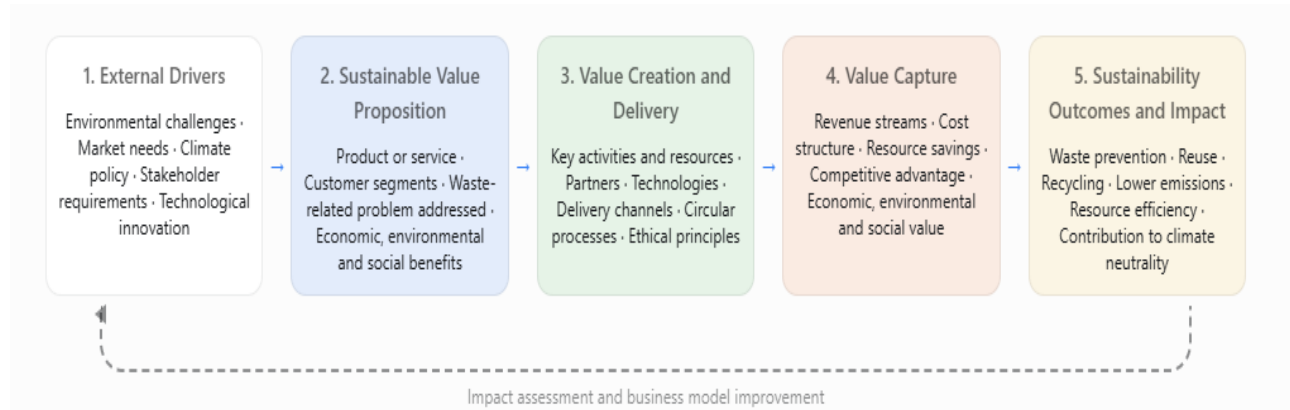


Fig. 3. Conceptual Framework of a Sustainable Business Model for Waste Management Start-ups

Source: adapted by the authors based on data from [7; 8]

The value proposition of a sustainable business model comprises two interconnected levels: tangible and intangible. The tangible level encompasses the products and services offered by the enterprise, whereas the intangible level reflects its mission, strategic objectives, entrepreneurial vision, values, and beliefs. Combining these levels makes it possible to formulate a proposition that not only meets consumer needs but also generates positive economic, environmental, and social impacts. Integrating sustainability principles into the enterprise's mission, strategy, and value system directly influences its managerial decisions, corporate behaviour, accountability to stakeholders, and long-term performance [11].

The second key element of a sustainable business model is the value creation and delivery system. It defines the organisational and operational mechanism through which the value proposition is implemented and encompasses the resources, processes, technologies, and partnerships required to ensure the sustainable development of a start-up. Its main components include supply chain and logistics management, operations, marketing and sales, innovation, human resource management, corporate governance, and organisational culture [10; 11]:

- supply chain management encompasses supplier selection, procurement, transportation, raw material storage, and finished-product distribution. Within a sustainable business model, preference is given to environmentally and socially responsible suppliers, local resources, secondary raw materials, and low-carbon logistics solutions. Optimising material flows helps reduce costs, emissions, and dependence on primary resources;

- operations encompass the production of goods or provision of services, management of technological processes, quality control, and improvement of resource-use efficiency. Transforming operations in accordance with sustainability principles involves waste prevention, energy and water conservation, the use of renewable energy sources, material reuse, and the implementation of circular production processes;

- marketing and sales communicate the value proposition to consumers and other stakeholders. Sustainable marketing should be based on transparency, the credibility of environmental and social claims, ethical conduct, and informing consumers about product impacts throughout the life cycle. It also involves preventing greenwashing and promoting responsible consumption;

- innovation, design, research, and development are the principal drivers of business model transformation. They involve developing environmentally safe, economically viable, and socially responsible products, services, and technologies. Particular importance is attached to eco-design, the use of innovative and secondary materials, improved product reparability and durability, and the development of digital solutions for optimising resource flows;

- human resource management encompasses the recruitment, development, and retention of employees whose competencies align with strategic sustainability objectives. It involves creating safe and

inclusive working conditions, ensuring equal opportunities, supporting continuous learning, developing environmental and digital competencies, and engaging employees in innovation activities;

–corporate governance ensures transparency, accountability, compliance with ethical standards, risk management, and consideration of the interests of different stakeholder groups. Integrating environmental, social, and governance criteria into decision-making makes it possible to align the enterprise's current activities with its long-term objectives;

–organisational culture shapes the enterprise's values, behavioural norms, and responses to emerging challenges and opportunities. A sustainability-oriented culture promotes innovation, responsibility, partnership, resource efficiency, and the continuous improvement of business processes.

Thus, the value creation and delivery system is a comprehensive mechanism that integrates all functional areas of the enterprise. Its effectiveness depends on aligning resources, processes, technologies, and partnerships with the stated value proposition. Such a system ensures not only the economic viability of a start-up but also a reduction in its negative environmental impact, stronger social responsibility, and the formation of long-term competitive advantages.

The third element of a sustainable business model is value capture, which reflects the ways in which created and delivered value is converted into economic returns, environmental impacts, and social benefits. From an economic perspective, it encompasses the formation of revenue streams, the cost structure and pricing mechanisms, cash-flow management, customer acquisition and retention, market development, and the enterprise's investment attractiveness.

Unlike a traditional business model, value capture within a sustainable business model is not limited to maximising profit or shareholder value. It provides for the equitable distribution of created benefits among the enterprise, consumers, employees, partners, investors, territorial communities, and other stakeholders. Stable financial flows enable further investment in technological innovation, the expansion of market opportunities, and the implementation of environmental and social initiatives.

Environmental value is generated by reducing the consumption of primary resources, preventing waste generation, reusing and recovering materials, lowering emissions, and applying environmentally sound technologies. For waste-management start-ups, it may also involve returning secondary raw materials to economic circulation, extending product life cycles, and reducing the volume of waste sent to landfill.

Social value lies in creating safe jobs, developing professional competencies, improving the quality of life of consumers and local residents, ensuring access to beneficial goods and services, and supporting responsible production and consumption. At the same time, the economic, environmental, and social outcomes achieved should be evaluated using appropriate financial and non-financial indicators. This provides feedback and enables the continuous improvement of the business model.

Thus, value capture within a sustainable business model is a multidimensional process that combines the enterprise's financial viability with positive environmental and social outcomes. Accordingly, a sustainable business model may be defined as the logic of conducting entrepreneurial activity that ensures the creation, delivery, and capture of economic, environmental, and social value for a broad range of stakeholders, generates competitive advantages for the enterprise, and contributes to the sustainable development of society [9].

One of the key challenges in developing sustainable business models is enabling companies to generate economic returns while simultaneously creating social and environmental benefits. Although improvements in operational efficiency and product quality can directly contribute to higher profitability, it is also essential to understand how social and environmental value can be converted into economic value and become a source of competitive advantage.

To address this issue, it is useful to consider the classification of sustainable business model archetypes. These archetypes represent groups of mechanisms, principles, and practical solutions that support the development of business models for sustainability and help identify the means through which long-term sustainability can be achieved. Sustainable business model archetypes can therefore be defined as recurring patterns or conceptual frameworks that companies apply to integrate sustainability principles into their activities while maintaining economic viability and strengthening their competitive position.

According to the dominant type of business model innovation, sustainable business model archetypes can be classified into three broad categories: technological, social, and organisational archetypes. Each category reflects a particular approach to transforming the mechanisms of value creation, value delivery, and value capture (table 2).

Technological archetypes encompass business models primarily focused on technological innovation, including the optimisation of production processes, improvements in material and energy efficiency, reductions in costs, waste and emissions, as well as product improvements aimed at enhancing functionality and environmental performance. The implementation of such solutions contributes to the more efficient use of resources and strengthens a company's competitive position.

Table 2

Sustainable Business Model Archetypes for Waste Management

<i>Archetype</i>	<i>Characteristics</i>	<i>Value proposition</i>	<i>Core business models and practices</i>	<i>Monetisation mechanisms</i>
1	2	3	4	5
<i>Technological</i>				
Maximise Material and Energy Efficiency	Reducing material and energy consumption, waste generation, and emissions through technological and operational optimisation	Products and services characterised by lower resource consumption, reduced costs, and a smaller environmental footprint	low-carbon and lean manufacturing; additive manufacturing; dematerialisation of products and packaging; enhanced product functionality; energy-efficient solutions	savings on energy and resources; sale of energy-efficient technologies; licensing; payment based on achieved savings; investment incentives
Create Value from Waste	Transforming waste and by-products into resources by closing material loops and returning secondary raw materials to economic circulation	Reducing landfill disposal and the consumption of primary resources while creating new economic value from waste streams	circular economy; closed-loop systems; cradle-to-cradle; industrial symbiosis; reuse; repair; recycling; refurbishment and remanufacturing; extended producer responsibility; reverse logistics	sale of secondary raw materials and remanufactured products; waste collection and recycling fees; service contracts; technology licensing; savings on primary raw materials
Substitute with Renewables and Natural Processes	Replacing non-renewable resources, hazardous materials, and conventional technologies with renewable energy, biological resources, and nature-based processes	Environmentally safer products and production processes with lower carbon and resource footprints	renewable energy; green chemistry; biomimicry; blue economy; nature-based solutions; zero-waste and low-carbon production	sale of renewable energy and environmentally friendly products; energy service contracts; licensing; grants and investment incentives; savings on raw materials and energy
<i>Social</i>				
Deliver Functionality Rather than Ownership	Shifting from product sales to the provision of functionality or outcomes through servitisation, rental, leasing, or pay-per-use arrangements	Access to the required function without product ownership, combined with greater convenience, durability, and efficiency of use	product-service systems; rental; leasing; subscription; sharing models; <i>pay-per-use</i> and <i>pay-per-result</i> models; design-build-finance-operate models; chemical management services	rental fees; subscription payments; payment per use or result; service fees; maintenance services; extended warranties
Adopt a Stewardship Role	Managing the environmental and social impacts of products and business activities throughout their life cycle while considering stakeholder interests	Safe, ethical, and transparent products and services that contribute to consumer well-being, social welfare, and environmental protection	product stewardship; ethical and fair trade; biodiversity conservation; supply-chain transparency; product take-back programmes; responsible resource management	premium pricing for responsible products; service contracts; fees for product return, repair, and recycling; long-term partnership agreements; reputational benefits
Encourage Sufficiency	Reducing excessive production and consumption by promoting product durability, reparability, responsible use, and demand management	Meeting consumer needs with minimum resource use and an extended product life cycle	durable and modular design; repair and upgrading; slow fashion; consumer education; demand management; responsible marketing; multifunctional products	sale of durable and resource-efficient products; premium pricing; repair and upgrading services; subscriptions; sharing services; after-sales services

Continuation of Table 2

1	2	3	4	5
Inclusive Value Creation	Integrating vulnerable and underrepresented groups into value chains as employees, entrepreneurs, suppliers, and consumers while ensuring equitable access to goods, services, technologies, and economic opportunities	Affordable products and services, decent employment, broader economic opportunities, and a more equitable distribution of created value	inclusive business models; social enterprises; base-of-the-pyramid models; fair trade; frugal and accessible innovation; local supply chains; employment and professional integration programmes	sale of affordable products and services; differentiated pricing; social contracting; impact investment; grants and subsidies; payment for achieved social outcomes
<i>Organisational</i>				
Repurpose the Business for Society and the Environment	Prioritising a social or environmental mission while maintaining the economic viability of the organisation	Addressing specific social and environmental problems and generating positive impacts for territorial communities and other stakeholders	social entrepreneurship; hybrid organisations; cooperatives; mutual organisations; localised business models; regenerative initiatives	revenues from goods and services; socially responsible and impact investment; grants; subsidies; contracts for socially significant services
Develop Scale-Up Solutions	Expanding effective sustainable solutions at the regional, national, or international level to increase their aggregate environmental and social impact	Scalable positive social and environmental effects combined with the economic viability of the proposed solution	franchising; licensing; open innovation platforms; business incubators and accelerators; crowdsourcing; strategic partnerships; public-private partnerships	licensing and franchising fees; commercial contracts; platform commissions; public-private financing; investment; technology sales and transfer
Building Collaborative Ecosystems	Bringing together businesses, public authorities, research institutions, civil society organisations, and consumers to share resources, knowledge, infrastructure, and technologies and jointly address complex social and environmental challenges	Integrated sustainable solutions that individual actors could not develop independently, created through the synergy of complementary resources, competencies, and infrastructure	innovation ecosystems; cross-sector partnerships; industrial clusters; eco-industrial parks; public-private partnerships; shared digital platforms; consortia; collaborative research and innovation projects	membership and platform fees; revenues from joint projects; sharing of revenues and cost savings; grant funding; technology licensing and transfer; public-private partnership contracts

Source: the table has been systematized and adapted from [9; 11]

Social archetypes are based on innovations that transform the way businesses interact with consumers and society. They involve the introduction of new service models, improved accessibility of goods and services, the promotion of responsible consumer behaviour, the inclusion of vulnerable and underrepresented groups in value-creation chains, and support for socially significant initiatives.

Organisational archetypes focus on transforming business objectives, structures and organisational practices. They encompass the redefinition of corporate fiduciary responsibility, the integration of sustainability principles into corporate strategy, the development of collaborative ecosystems, and new models of stakeholder engagement.

Such archetypes enable companies to align their economic interests with social and environmental priorities and to make more effective use of the resources, knowledge, technologies and infrastructure available within partnerships.

Thus, these archetypes facilitate the integration of sustainability principles into business objectives, processes and organisational structures, enhancing the effectiveness of innovation, accelerating its implementation, reducing risks, and creating additional opportunities for monetising business ideas. The proposed categorisation is intended not only to minimise the negative social and environmental impacts of business activities but also to fundamentally rethink the ways in which value is created, delivered and captured while ensuring the financial viability of the business.

Start-ups may apply one or combine several archetypes when developing and transforming their business models. This enables them to identify new ways of creating and delivering sustainable value, structure innovative solutions, and establish practical guidelines for exploiting identified opportunities. Although each archetype may be applied independently, combining them often produces more comprehensive economic, social and environmental outcomes [12; 13].

Education and capacity building are essential prerequisites for the successful development and implementation of sustainable business models. Particular attention should be given to young people, whose entrepreneurial initiative, digital competencies, and openness to innovation can accelerate the transition towards circular, low-carbon, and socially inclusive economic practices. Integrating sustainable entrepreneurship, circular economy principles, systems thinking, and business modelling into formal and non-formal education can equip young people with the knowledge and practical skills required to identify sustainability challenges, develop viable business solutions, and assess their economic, environmental, and social impacts. Universities, business incubators, accelerators, and innovation hubs can support this process through interdisciplinary programmes, mentoring, project-based learning, start-up competitions, and cooperation with businesses, public authorities, and civil society organisations.

Such educational initiatives also create favourable conditions for implementing the inclusive value creation model, which seeks to ensure equitable access to knowledge, technologies, goods, services, employment, and entrepreneurial opportunities. Involving young people, vulnerable groups, local residents, and other underrepresented stakeholders in the development of sustainable solutions broadens participation in value-creation processes and enables social and environmental challenges to be addressed more comprehensively. Within this model, value is created not only for individual enterprises and consumers but also for a wider range of stakeholders through competence development, expanded economic opportunities, improved access to innovation, and positive social and environmental impacts.

At the same time, universities, innovation hubs, enterprises, public authorities, investors, and civil society organisations can contribute to the development of the collaborative ecosystem model. This model is based on cross-sectoral cooperation, the joint use of knowledge, technologies, resources, and infrastructure, as well as the distribution of roles and responsibilities among ecosystem participants. Such cooperation facilitates the transformation of innovative ideas into viable sustainable business solutions, reduces resource and knowledge constraints, accelerates the testing and scaling of innovations, and strengthens the capacity of enterprises to respond to complex sustainability challenges. Thus, educational initiatives contribute not only to the development of individual competencies but also to building an entrepreneurial culture focused on responsible innovation, inclusive participation, collaborative interaction, and sustainable value creation.

A practical example of the combined application of these models was the three-day workshop "*Climate-Neutral Waste Management as a Tool for the Sustainable Development of the City of Khmelnytskyi*", implemented by Leonid Yuzkov Khmelnytskyi University of Management and Law within the U CAN project (*Associating Ukrainian Cities to the Climate-Neutral and Smart Cities Mission*) [20]. The workshop engaged young people in developing circular and climate-neutral waste management solutions, applying sustainable business modelling tools, and transforming environmental challenges into viable entrepreneurial initiatives. It reflected the inclusive value creation model by providing young people with access to knowledge, practical tools, and opportunities to participate in addressing urban environmental challenges. Simultaneously, it embodied the collaborative ecosystem model by bringing together representatives of education, public authorities, business, and other stakeholders to exchange knowledge and jointly develop sustainable solutions. These practice-oriented educational activities strengthened young people's competencies in the circular economy, responsible entrepreneurship, teamwork, and sustainable value creation, while also contributing to the achievement of the city's climate-neutrality objectives.

Sustainable business models can also serve as a means of aligning technological, social and organisational innovations with sustainability objectives at the systemic level, thereby supporting their integration and scaling. The diffusion of such models depends on their capacity to demonstrate measurable economic, social and environmental benefits that can be adapted to different business processes, industries and territories. Consequently, new standards and business practices emerge that can support systemic transformations and contribute to the achievement of sustainable development goals.

Conclusions from the conducted research. The study confirmed that sustainable business models enable start-ups and established enterprises to integrate economic, environmental, and social objectives while ensuring long-term financial viability. Three interrelated groups of archetypes have been identified: technological, social, and organisational. They promote resource and energy efficiency, waste valorisation, responsible consumption, social inclusion, business transformation, and the scaling of sustainable solutions.

Particular importance is attached to inclusive value creation models, which broaden access to knowledge, resources, employment, and entrepreneurial opportunities, and collaborative ecosystem models based on cooperation among enterprises, research institutions, public authorities, investors, and civil society organisations. Their implementation requires combining appropriate archetypes, integrating circular economy and low-carbon principles, developing cross-sectoral partnerships, applying scaling mechanisms, and assessing economic, environmental, and social impacts.

Hybrid business models combining these archetypes offer the greatest potential for creating sustainable value, reducing risks, attracting investment, and strengthening competitiveness. Further research should focus on developing a methodological approach to assessing the sustainability of business models and testing the proposed classification across enterprises in different economic sectors.

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СТАЛІ БІЗНЕС-МОДЕЛІ УПРАВЛІННЯ ВІДХОДАМИ ЯК ІНСТРУМЕНТ ДОСЯГНЕННЯ КЛІМАТИЧНОЇ НЕЙТРАЛЬНОСТІ

Мета. Дослідження теоретичних засад формування сталих бізнес-моделей, систематизація їхніх основних архетипів та визначення можливостей їх застосування й поєднання стартапами і діючими підприємствами для вдосконалення управління відходами, створення економічної, екологічної та соціальної цінності й досягнення кліматичної нейтральності.

Методика дослідження. Для досягнення поставленої мети використано методи аналізу та синтезу – для розкриття сутності сталих бізнес-моделей і визначення їхньої ролі в управлінні відходами; монографічний метод – для опрацювання наукових підходів до формування бізнес-моделей сталого розвитку; порівняльний – для встановлення відмінностей між традиційними та сталими бізнес-моделями; класифікації – для систематизації їхніх архетипів; абстрактно-логічний та узагальнення – для формулювання висновків і практичних рекомендацій.

Результати дослідження. Розкрито сутність сталих бізнес-моделей як інструменту поєднання економічної результативності з ресурсоефективністю, скороченням відходів і викидів та створенням суспільної цінності. Систематизовано технологічні, соціальні й організаційні архетипи сталих бізнес-моделей. Визначено їхні можливості щодо запобігання утворенню відходів, повторного використання, ремонту, перероблення, відновлення ресурсів та створення цінності з відходів. Обґрунтовано доцільність застосування гібридних бізнес-моделей, які поєднують кілька архетипів. Розкрито зміст моделей інклюзивного створення цінності та партнерських екосистем, заснованих на залученні підприємств, наукових установ, органів публічної влади, інвесторів і громадських організацій. Визначено роль освіти та розвитку компетентностей молоді у формуванні циркулярних підприємницьких рішень.

Наукова новизна результатів дослідження. Удосконалено систематизацію сталих бізнес-моделей управління відходами шляхом доповнення технологічних, соціальних та організаційних архетипів моделями інклюзивного створення цінності й партнерських екосистем, що дає змогу комплексно враховувати економічні, екологічні та соціальні результати їх впровадження.

Практична значущість результатів дослідження. Результати дослідження можуть використовуватися стартапами і діючими підприємствами для розроблення та трансформації бізнес-моделей у сфері управління відходами, органами публічної влади – для підтримки циркулярних і кліматично нейтральних ініціатив, а закладами освіти та інноваційними центрами – для підготовки й реалізації навчальних програм із сталого підприємництва.

Ключові слова: сталі бізнес-моделі, управління відходами, кліматична нейтральність, циркулярна економіка, архетипи бізнес-моделей, ресурсоефективність, створення цінності з відходів, інклюзивне створення цінності, партнерські екосистеми, стартапи, сталий розвиток.

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SUSTAINABLE WASTE MANAGEMENT BUSINESS MODELS AS A TOOL FOR ACHIEVING CLIMATE NEUTRALITY

Purpose. The aim of the study is to examine the theoretical foundations of formation of sustainable business models, systematise their main archetypes, and identify opportunities for their application and combination by start-ups and established enterprises to improve waste management, create economic, environmental, and social value, and achieve climate neutrality.

Methodology of research. To achieve the stated purpose, the following research methods have been employed: analysis and synthesis – to reveal the essence of sustainable business models and determine their role in waste management; the monographic method – to examine scholarly approaches to the formation of business models for sustainable development; the comparative method – to identify differences between traditional and sustainable business models; classification – to systematise their archetypes; and abstract-logical reasoning and generalisation – to formulate conclusions and practical recommendations.

Findings. The essence of sustainable business models is revealed as a tool for combining economic performance with resource efficiency, waste and emissions reduction, and the creation of societal value. The technological, social, and organisational archetypes of sustainable business models have been systematised. Their potential for waste prevention, reuse, repair, recycling, resource recovery, and value creation from waste has been identified. The feasibility of applying hybrid business models that combine several archetypes has been substantiated. The content of inclusive value creation and collaborative ecosystem models based on the involvement of enterprises, research institutions, public authorities,

investors, and civil society organisations has been disclosed. The role of education and youth competence development in designing circular entrepreneurial solutions has been determined.

Originality. The systematisation of sustainable business models for waste management has been improved by supplementing technological, social, and organisational archetypes with inclusive value creation and collaborative ecosystem models. This makes it possible to comprehensively consider the economic, environmental, and social outcomes of their implementation.

Practical value. The research findings can be used by start-ups and established enterprises to develop and transform business models in the waste management sector; by public authorities to support circular and climate-neutral initiatives; and by educational institutions and innovation centres to design and implement educational programmes in sustainable entrepreneurship.

Key words: sustainable business models, waste management, climate neutrality, circular economy, business model archetypes, resource efficiency, value creation from waste, inclusive value creation, collaborative ecosystems, start-ups, sustainable development.

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