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Article

Theoretical and Methodological Foundations for Improving Environmental Cost Accounting

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Abstract: This study examines the economic substance of environmental costs and develops methodological approaches to their classification and accounting at enterprises. The study reviews Environmental Management Accounting (EMA), Material Flow Cost Accounting (MFCA), Activity-Based Costing (ABC), ISO 14051 and ISO 14007, as well as selected Japanese and European practices. A multidimensional classification of environmental costs is proposed according to environmental purpose, economic substance, relationship with production, environmental impact, resource type, and accounting object. The paper also develops an integrated model linking monetary information with physical flows of materials, energy, water, emissions, and waste. The proposed approach can improve cost allocation, product costing, resource-efficiency assessment, and management decision-making. The findings are particularly relevant to the adaptation of international environmental accounting practices to the institutional, regulatory, and technological conditions of Uzbekistan.

Keywords: environmental costs, environmental management accounting, EMA, material flow cost accounting, MFCA, activity-based costing, ABC, material flows, cost drivers, product costing, environmental performance, management accounting.

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1. Introduction

As the dependence of economic activity on environmental factors intensifies, environmental protection is no longer limited to enterprises' environmental policies; it increasingly affects cost management, product cost formation, and the assessment of financial results. The use of raw materials, water, and energy in production, the generation of waste, emissions and wastewater, and measures aimed at reducing environmental risks require a certain amount of enterprise resources.

In Uzbekistan, the relevance of this issue is increasing as environmental regulation develops. The environmental legislation of the Republic of Uzbekistan also provides for economic relations associated with environmental impacts. In particular, Article 34 of the Law of the Republic of Uzbekistan "On Nature Protection" provides for compensation payments related to the use of natural resources, environmental pollution, waste disposal, and greenhouse-gas emissions, as well as payments for the protection and restoration of natural resources. At the same time, the payment of such charges does not release an enterprise from its obligations to implement environmental measures or compensate for environmental damage [1].

Resolution No. 916 of the Cabinet of Ministers of the Republic of Uzbekistan dated December 30, 2024 is aimed at improving control over the circulation of waste, certain

hazardous products, and chemicals and establishing the relevant electronic information exchange. Resolution No. 85 of the Cabinet of Ministers dated February 28, 2026 establishes incentive mechanisms aimed at reducing the adverse environmental impact of industrial enterprises classified as Categories I and II [2].

Under these conditions, it is important not to allow information on environmental costs to become "hidden" within aggregate costs, but rather to link such costs to their causes and environmental outcomes. A methodological document of the United Nations on environmental management accounting notes that environmental management accounting serves to integrate information from financial accounting, cost accounting, and physical material balances.

The purpose of the study is to systematize the economic substance of environmental costs, develop a multidimensional classification, and formulate a methodological model consistent with international approaches for organizing analytical accounting at enterprises in Uzbekistan.

The scientific novelty of the study lies in the proposed identification of environmental costs along the chain "environmental purpose – economic substance – environmental impact – technological process – cost center – cost driver – product," as well as in the integration of EMA, MFCA, and ABC approaches within a unified accounting model [3].

The theoretical foundations of environmental cost accounting have developed at the intersection of environmental accounting, management accounting, and environmental management. Burritt, Hahn, and Schaltegger view environmental management accounting as a comprehensive approach for generating monetary and non-monetary environmental information for internal management. In their approach, one of the key functions of EMA is the joint management of environmental and economic performance indicators.

The integrated EMA concept proposed by Burritt, Hahn, and Schaltegger is intended to bring different environmental management accounting tools together within a common theoretical framework [4]. This approach substantiates the need to link environmental information with management actors and managerial decisions.

Jasch emphasizes the importance of linking financial accounting, cost accounting, and material-balance information when identifying environmental costs. Such integration helps identify opportunities to improve material efficiency and reduce environmental protection costs.

The 2005 IFAC international guidance document established a common conceptual and practical methodological basis for EMA. The document is oriented toward the joint use of environmental and economic information in management decision-making [5].

MFCA is particularly important for linking environmental costs with physical flows. ISO 14051:2011 establishes a general framework for tracking material flows and stocks in physical units and assessing the costs associated with those flows. The standard was reviewed and reaffirmed in its current form in 2025.

In their review of MFCA research, Christ and Burritt highlight the method's potential to improve economic and environmental performance simultaneously, while noting that the empirical evidence base remains limited in certain areas of practical application.

Kokubu and Kitada focus on the integration of MFCA with existing management practices in enterprises and emphasize the need for organizational alignment to ensure its continuous application. Subsequent studies have also empirically examined the relationship between MFCA and environmental and economic performance. Nishitani and co-authors show that MFCA can improve environmental and economic outcomes simultaneously by increasing resource-use efficiency.

ISO 14007:2019 provides organizations with guidance for determining costs and benefits associated with environmental aspects, environmental impacts, and dependencies on natural resources [6].

In Japan, the internal management function of environmental accounting has been particularly well developed. The Japanese Ministry of the Environment's Environmental Accounting Guidelines 2005 provide for the introduction of environmental accounting, the preparation of comparable information, and its use for internal management purposes.

In the European Union, EMAS has developed as a system integrating environmental management, environmental-performance assessment, and information disclosure. The European Commission describes EMAS as a management instrument supporting the assessment, reporting, and improvement of environmental performance.

The literature review therefore identifies three major research directions: EMA integrates environmental and economic information; MFCA links physical material flows with costs; and ABC allocates costs through the activities and drivers that generate them [7]. Integrating these approaches with the existing accounting systems of enterprises in Uzbekistan appears promising from both scientific and practical perspectives.

2. Materials and Methods

The study employed a systems approach, comparative analysis, grouping, classification, economic-logical modeling, and conceptual design.

The information base of the study consisted of international standards and methodological documents, academic articles, international guidance on environmental management accounting, and sources relating to the environmental and accounting legislation of the Republic of Uzbekistan.

Methodologically, the study was based on the integration of three information layers:

1. *monetary information – environmental measures, services, payments, and other costs;*
2. *physical information – quantities of raw materials, materials, water, energy, waste, and emissions;*
3. *management information – cost centers, product costs, cost drivers, and environmental outcomes.*

Under IAS 2 "Inventories," costs included in the cost of inventories comprise costs of purchase, conversion, and other costs incurred in bringing inventories to their present location and condition; appropriate production overheads may also be included in cost under the relevant conditions. Therefore, rather than automatically classifying environmental costs as either "product cost" or "period expense," it is methodologically more appropriate to determine their economic function within the production process.

The conceptual model of the study was formulated as follows: environmental event → physical flow → monetary valuation → classification → cost center → cost driver → product/cost → environmental outcome → economic effect → management decision.

3. Results

Limiting environmental costs to environmental payments made to the government narrows the economic information available on an enterprise's environmental activities. To comply with environmental requirements, an enterprise may incur expenditures on treatment facilities, filters, monitoring equipment, laboratory services, waste transportation and disposal, environmental audits, certification, and environmental innovations.

On this basis, environmental costs can be defined as follows:

"Environmental costs are economic resources, measured in monetary terms, incurred by an enterprise to prevent, reduce, control, or eliminate environmental impacts arising from its

production and business activities, to use natural resources efficiently, and to fulfill environmental obligations."

This definition highlights two dimensions of environmental costs. The first comprises direct monetary expenditures, including treatment, monitoring, waste disposal, environmental payments, and related costs. The second reflects the economic value of resource losses, including raw materials, energy, and labor resources converted into waste [8].

Table 1 presents a proposed classification of environmental costs according to their economic substance.

The practical significance of this classification is that it enables environmental costs to be analyzed not only in monetary terms but also in terms of the reasons for their occurrence and their management purpose. This provides a methodological basis for subsequently establishing the environmental component of enterprise costs as separate analytical accounting objects.

Environmental costs may simultaneously possess several economic characteristics. For example, the cost of disposing of production waste can be classified, by economic substance, as the cost of an external service; by environmental purpose, as a remediation cost; by its relationship with production, as an indirect cost; and by environmental impact, as a waste-related cost.

Therefore, the study proposes accounting for environmental costs on the basis of multidimensional analytical identification rather than a single classification criterion [9].

Table 1. Classification of environmental costs according to their economic substance

Environmental cost group	Description	Significance for accounting
Prevention costs	Technical and organizational measures aimed at reducing pollution and waste generation	Enables assessment of the reduction of future environmental risks
Monitoring and control	Measurement and control of emissions, wastewater, waste, and resource consumption	Enables environmental indicators to be linked to costs
Treatment costs	Costs associated with treatment of air, water, and the production environment	Helps distinguish production and period expenses by relevant objects
Waste management	Collection, transportation, storage, recycling, and disposal	Enables determination of the actual cost associated with waste
Restoration and remediation	Restoration of the natural environment and land remediation	Supports assessment of future obligations and related costs
Environmental payments	Mandatory payments related to pollution, resource use, and other environmental obligations	Enables separate control of mandatory payments
Environmental audit and certification	Environmental audit, assessment, certification, and consulting	Enables assessment of the effectiveness of the environmental management system
Environmental innovations	Introduction of resource-efficient and environmentally safe technologies	Supports assessment of the environmental efficiency of expenditure and investment decisions

Table 2 presents a proposed multidimensional classification of environmental costs.

Table 2. Multidimensional classification of environmental costs

Classification criterion	Environmental cost group	Composition	Accounting function
By environmental purpose	Prevention	Clean technologies, filters, resource-efficient equipment	Identifying costs aimed at reducing environmental risks
	Control and monitoring	Laboratory work, measurement, monitoring, audit	Tracking environmental control costs
	Remediation	Treatment, disposal, waste neutralization	Managing the consequences of environmental damage
	Restoration	Land remediation, restoration of the natural environment	Separately monitoring restoration costs
By relationship with production	Direct	Directly related to a specific product or process	Direct inclusion in product cost
	Indirect	Common to several products or processes	Allocation through an appropriate allocation base
By economic substance	Material	Filters, reagents, chemicals, materials	Controlling material consumption
	Labor	Labor of environmental personnel	Determining labor costs
	Services	Disposal, monitoring, consulting	Determining external service costs
	Depreciation	Depreciation of environmental facilities and equipment	Determining costs of long-term environmental assets
By environmental impact	Atmosphere	Reduction of emissions	Controlling air pollution
	Water	Wastewater treatment	Protecting water resources
	Waste	Collection, transportation, recycling	Controlling waste flows
By resource type	Material	Raw materials and auxiliary materials	Determining material efficiency
	Energy	Electricity, gas, heat	Assessing energy efficiency
	Water	Process and auxiliary water	Managing water consumption

In particular, linking costs to the type of environmental impact and the technological process makes it possible to identify sources of environmental inefficiency in production.

This classification transforms environmental costs from a simple financial indicator into an object of management information.

Figure 1 presents the factors shaping the economic substance of environmental costs.

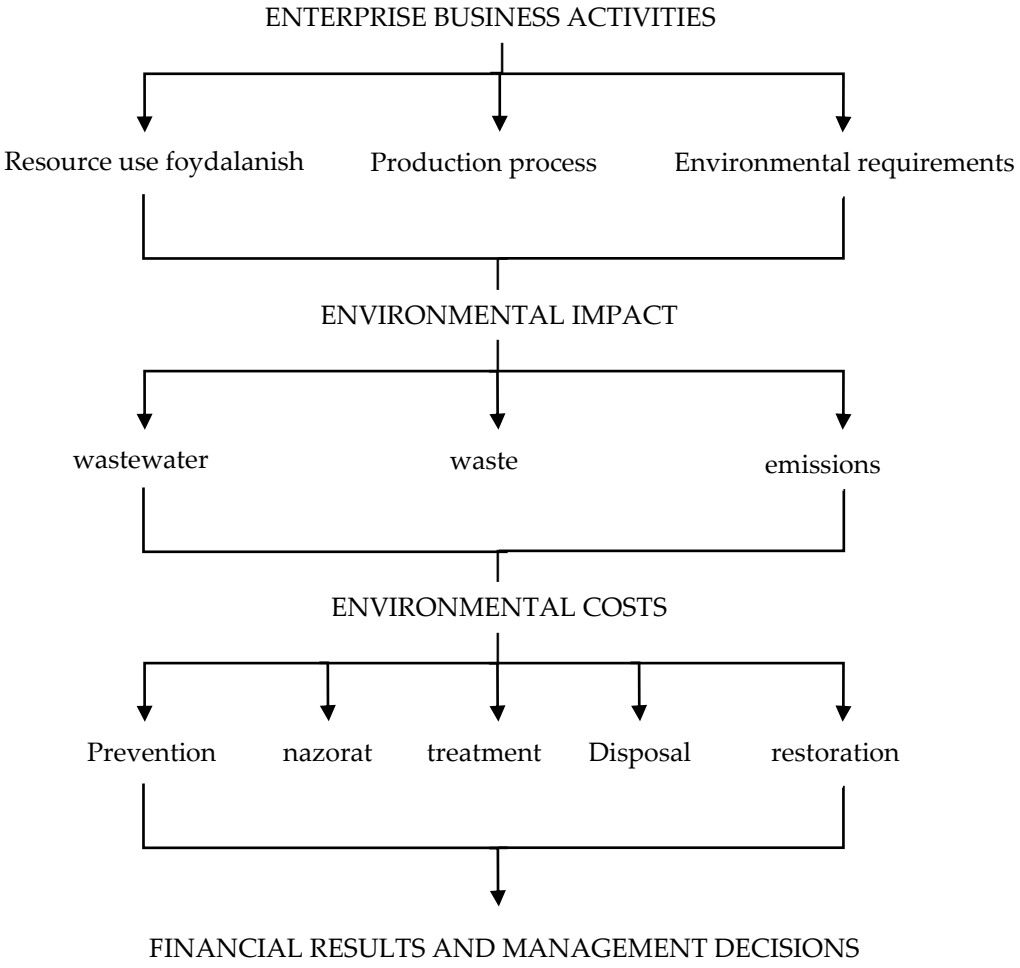


Figure 1. Factors shaping the economic substance of environmental costs

As shown in Figure 1, environmental costs originate from an enterprise's use of resources and production processes and arise through activities that affect the environment. These costs may, in turn, affect the formation of product costs, period expenses, asset values, or other relevant accounting objects.

At the same time, it is neither scientifically nor practically appropriate to regard all environmental costs as having the same economic nature. For example, there is an economic distinction between expenditures on introducing a new technology to prevent waste generation and expenditures on disposing of waste that has already been generated. In the first case, the enterprise uses resources to reduce future environmental impacts; in the second, it incurs costs to manage existing environmental consequences of the production process.

Effective management of environmental costs requires their identification within the enterprise's existing accounting system. Opening a separate synthetic account is not always necessary; within the accounting policy of the enterprise, relevant analytical subaccounts, cost centers, nomenclature codes, or environmental attributes may be introduced [10].

For example: environmental prevention costs; environmental monitoring costs; waste-management costs; environmental treatment costs; environmental payments; depreciation of environmental assets; and environmental innovation costs.

Such an analytical structure makes it possible to identify the environmental component without disrupting the existing financial accounting mechanism.

Under IAS 2 "Inventories," only costs associated with bringing inventories to their present location and condition are included in inventory cost; abnormal waste, unrelated administrative costs, and selling costs are recognized as period expenses. Accordingly, when classifying environmental costs, the primary criterion should be their economic function rather than merely their "environmental" label.

Allocating environmental costs among products simply in proportion to production volume may fail to reflect their actual causal basis. Therefore, the study proposes the use of environmental cost drivers (Table 3).

Table 3. Methodology for allocating environmental costs using cost drivers

Environmental cost type	Accounting object	Primary cost driver	Allocation/calculation basis	Management objective
Waste collection	Technological process	Waste volume, tonnes	By process	Reducing waste
Waste disposal	Cost center	Waste quantity	By product/process	Controlling disposal costs
Wastewater treatment	Production process	Water consumption, m^3	Based on water consumption	Improving water efficiency
Reduction of atmospheric emissions	Production unit/equipment	Emission volume	By emission source	Reducing pollution
Environmental monitoring	Cost center	Monitoring operations	By activity center	Optimizing control costs
Environmental audit	Enterprise	Audit scope	By period or activity	Assessing environmental management
Depreciation of environmental equipment	Environmental asset	Utilization rate	To production processes	Assessing equipment efficiency
Energy-efficiency measures	Technological process	kWh saved	By process efficiency	Reducing energy consumption
Material losses	Material flow	Volume of lost material	Based on MFCA	Improving resource efficiency

For example, linking wastewater-treatment costs to water consumption rather than to the quantity of products produced more accurately reflects the causal nature of the cost. Similarly, it is appropriate to link waste-disposal costs to the mass of waste generated rather than to production volume.

This approach is consistent with the causality principle of ABC methodology. As a result, the reason for the formation of the environmental component of product cost becomes more transparent.

A major problem in environmental cost accounting is the disconnection between monetary expenditures and the physical flow that gives rise to those expenditures. For example, an enterprise may obtain 850 kg of finished product and 150 kg of waste from 1,000 kg of raw materials. Conventional cost accounting shows the total cost of raw materials but may not separately identify the economic value associated with the 150 kg loss [11].

"MFCA is specifically designed to address this problem. ISO 14051 is based on tracking material flows in physical units and assessing the costs associated with those flows". ISO

Figure 2 presents a proposed model for integrating environmental costs with financial and physical information.

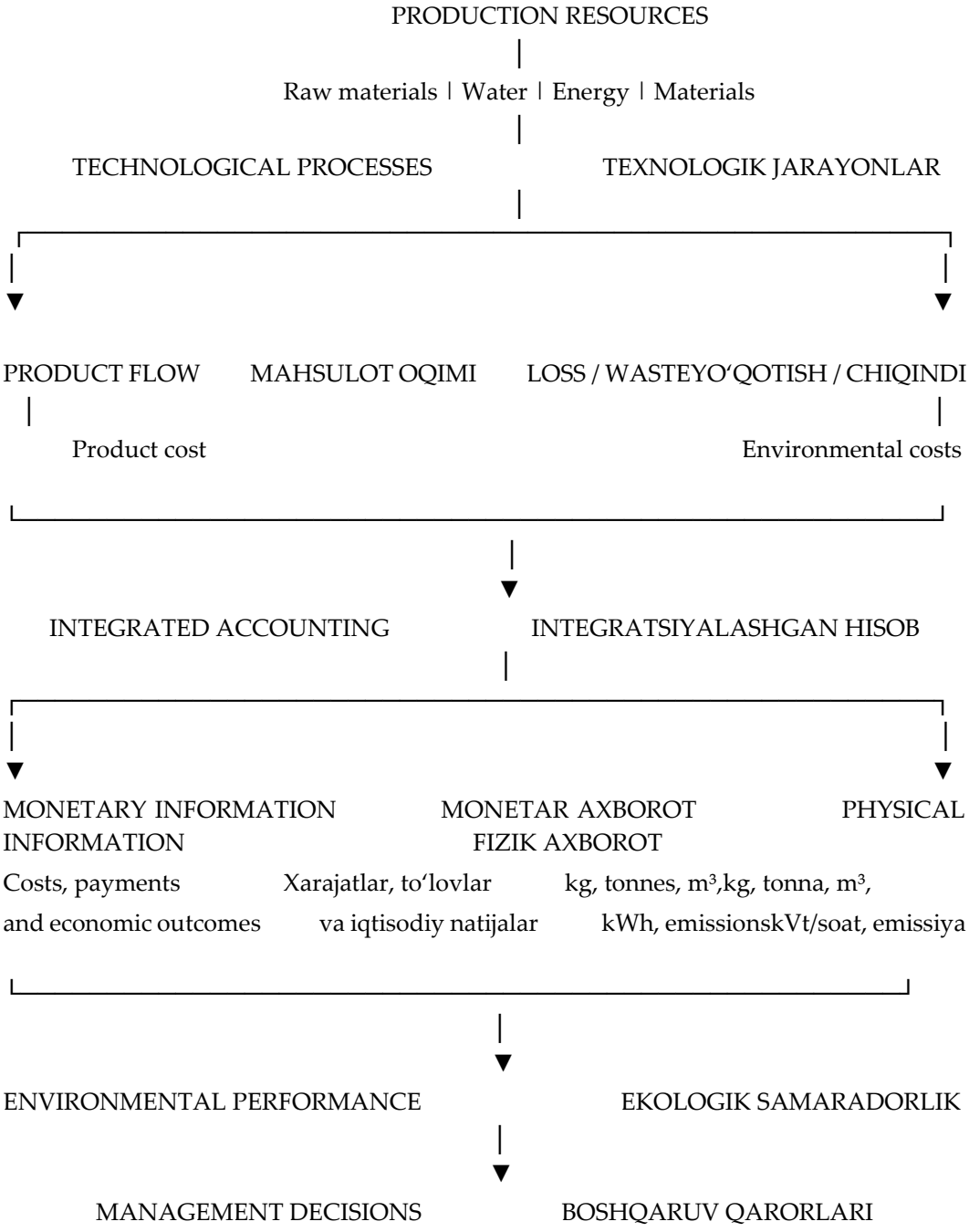


Figure 2. Model for integrating environmental costs with financial and physical information

Figure 2 demonstrates the need to link environmental cost accounting not only to accounting entries but also to physical information on material and energy flows. Under this approach, an enterprise can determine not only how much it has spent, but also which environmental process caused the expenditure.

For example, if a certain share of raw materials becomes waste during production, the resulting waste embodies not only disposal costs but also part of the value of the raw materials, energy consumption, labor costs, and production overheads incorporated in it. Therefore, environmental cost measurement should not be limited to waste-disposal expenditures; it should also identify hidden economic losses arising from inefficient use of resources.

This approach increases the strategic importance of environmental cost accounting. Accurate identification of environmental costs enables management to assess the economic efficiency of decisions such as modifying production technology, optimizing raw-material consumption, improving energy efficiency, recycling waste, or investing in new environmentally sound technologies.

A key advantage of MFCA is that it treats waste not merely as a physical object requiring disposal but as a loss embodying the economic value of resources previously consumed. Accordingly, the value of waste can be assessed as follows: waste value = raw-material value + energy costs + labor costs + relevant production overheads + disposal costs.

This does not mean that all components should automatically be recognized as expenses in financial reporting; rather, their economic value is determined for management analysis [12].

This distinction is methodologically important. MFCA information does not replace financial accounting; instead, it complements financial accounting with physical production information.

International practice does not provide a single universal model for environmental cost accounting. While IFAC has established EMA as a general methodological platform, ISO 14051 develops the physical-monetary mechanism of MFCA, and ISO 14007 develops guidance for determining environmental costs and benefits.

In the Japanese model, the joint presentation of environmental protection expenditures and environmental outcomes plays an important role. The European Union's EMAS system, in turn, emphasizes the integration of environmental management into the organization's overall management system.

For Uzbekistan, rather than directly replicating these practices, a combined approach appears appropriate: EMA + MFCA + ABC + environmental performance indicators + digital analytical accounting.

Under this approach, EMA provides the overall information concept; MFCA addresses physical flows and losses; ABC provides the causal allocation mechanism; and environmental performance indicators assess the outcomes of costs [13].

Within Uzbekistan's current regulatory environment, the transition to electronic information exchange related to waste and hazardous products is also strengthening the institutional basis for such integration. Resolution No. 916 provides for electronic information exchange concerning imports and exports of waste, hazardous products, and chemicals.

Similarly, Resolution No. 85 of 2026 establishes incentive mechanisms aimed at reducing the environmental impact of industrial enterprises, thereby increasing the managerial relevance of information on environmental costs.

The next stage in the development of environmental cost accounting is associated with integrating financial and physical data within a unified digital environment. ERP systems can provide financial and production data, IoT tools can provide water, energy, and emissions indicators, and BI tools can generate analytical reports.

The primary objective of such a system is not the technology itself but the automation of the following information chain: environmental event → physical measurement → cost → cost center → product → environmental outcome → economic effect.

On this basis, the following indicators can be generated regularly for enterprise management:

- total environmental costs;
- share of environmental costs in product cost;
- environmental cost per tonne of product;
- waste generated per tonne of product;
- water and energy consumption per unit of product;
- waste recycling rate;
- ratio of prevention costs to remediation costs;
- value of resources saved as a result of environmental measures.

These indicators shift the focus of environmental cost accounting from the question "How much was spent?" to "Why was it spent, and what result did it produce?"

4. Discussion

The study results make it possible to identify three major methodological problems in environmental cost accounting.

First, the identification problem. Environmentally related costs are dispersed across different accounts. Therefore, the enterprise's accounting policy should introduce analytical codes or a system of attributes that distinguish environmental costs [14].

Second, the allocation problem. Allocating all types of environmental costs in proportion to total production volume may distort causal relationships. It is therefore appropriate to use drivers such as waste, water, energy, emissions, or monitoring operations.

Third, the disconnection between physical and monetary information. If accounting data are not integrated with data from environmental, energy, production, and laboratory functions, the actual economic cause of environmental costs may remain unidentified [15].

To address these problems, the main components of the model proposed in this paper are as follows:

5. Conclusion

The study substantiates the need to treat environmental costs not as a secondary component of enterprise costs but as an independent object of economic and management information.

The economic substance of environmental costs is reflected in three key characteristics: they represent the consumption of economic resources, capture economic consequences associated with environmental impacts, and form an information base for management decision-making.

In addition to classifying environmental costs into prevention, control, environmental production, remediation, restoration, and compensation costs, the study proposes their parallel classification by economic substance, type of environmental impact, resource type, and accounting object.

One of the scientifically significant results is the development of an integrated environmental cost accounting model based on the principles of EMA + MFCA + ABC. This model makes it possible to link environmental costs with physical resource flows, cost centers, technological processes, and product cost.

The study also proposes using cost drivers such as waste quantity, water consumption, energy consumption, emissions volume, and monitoring operations when allocating environmental costs. Such an approach can reflect the causal basis of environmental costs more accurately.

The MFCA approach makes it possible to assess waste not merely as an object for disposal but as an economic expression of lost raw materials, energy, labor, and production resources. The current interpretation of ISO 14051 is likewise based on tracking material flows in physical units and assessing the costs associated with them.

Under the conditions of Uzbekistan, rather than directly transferring international practices, it is appropriate to adapt them to the national accounting system, environmental legislation, production technologies, and the digital capabilities of enterprises.

Accordingly, the principal scientific proposal of the paper is expressed through the following integrated model: "Environmental event → physical flow → monetary valuation → multidimensional classification → cost center → environmental cost driver → product/cost → environmental outcome → economic effect → management decision."

This model can serve as a methodological basis for improving environmental cost accounting, forming more accurate product costs, identifying resource losses, and assessing the economic efficiency of environmental measures.

REFERENCES

[1] Republic of Uzbekistan. "Law on Nature Protection," No. 754-XII, December 9, 1992, current version. https://lex.uz/ru/docs/-107115.

[2] Cabinet of Ministers of the Republic of Uzbekistan. (2024, December 30). "On measures to further improve control over the circulation of waste, certain types of hazardous products and chemicals in the territory of the Republic of Uzbekistan," Resolution No. 916. https://lex.uz/docs/-7308091.

[3] Cabinet of Ministers of the Republic of Uzbekistan. (2026, February 28). "On measures to encourage actions aimed at reducing the adverse environmental impact of industrial enterprises," Resolution No. 85. https://lex.uz/uz/docs/-8068163.

[4] United Nations Division for Sustainable Development. (2001). Environmental management accounting: Procedures and principles. United Nations Department of Economic and Social Affairs. https://www.un.org/esa/sustdev/publications/proceduresandprinciples.pdf.

[5] Burritt, R. L., Hahn, T., & Schaltegger, S. (2002). An integrative framework of environmental management accounting – Consolidating the different approaches of EMA into a common framework and terminology. In M. Bennett & J. J. Bouma (Eds.), Environmental management accounting: Informational and institutional developments. Kluwer Academic Publishers. The Australian National University.

[6] Jasch, C. (2003). The use of Environmental Management Accounting (EMA) for identifying environmental costs. Journal of Cleaner Production, 11(6), 667–676. https://doi.org/10.1016/S0959-6526(02)00107-5

[7] International Federation of Accountants. (2005). International guidance document: Environmental management accounting. IFAC.

[8] ISO. ISO 14051:2011. Environmental management – Material flow cost accounting – General framework. International Organization for Standardization, 2011. Current version reaffirmed in 2025. https://www.iso.org/standard/50986.html

[9] Christ, K. L., & Burritt, R. L. (2015). Material flow cost accounting: A review and agenda for future research. Journal of Cleaner Production, 108, 1378–1389. https://doi.org/10.1016/j.jclepro.2014.09.005

[10] Kokubu, K., Kitada, H., Nishitani, K., & Shinohara, A. (2023). How material flow cost accounting contributes to the SDGs through improving management decision-making. Journal of Material Cycles and Waste Management, 25, 2783–2793. https://doi.org/10.1007/s10163-023-01696-7

[11] Nishitani, K., Kokubu, K., Wu, Q., Kitada, H., Guenther, E., & Guenther, T. (2022). Material flow cost accounting (MFCA) for the circular economy: An empirical study of the triadic relationship between MFCA, environmental performance, and the economic performance of Japanese companies. Journal of Environmental Management, 303, 114219. https://doi.org/10.1016/j.jenvman.2021.114219

[12] International Organization for Standardization. (2019). ISO 14007:2019 Environmental management – Guidelines for determining environmental costs and benefits. ISO. Geneva: ISO, 2019. https://www.iso.org/ru/standard/70139.html

[13] Ministry of the Environment, Government of Japan. (2005). Environmental accounting guidelines 2005. Government of Japan. env.go.jp

[14] European Commission. (n.d.). Eco-Management and Audit Scheme (EMAS). European Commission. Green Forum.
[15] International Financial Reporting Standards Foundation. (n.d.). IAS 2 Inventories. IFRS Foundation.