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CONTENTS

FOREIGN EXPERIENCE IN THE EFFECTIVE ORGANIZATION OF FREE ECONOMIC ZONES	51
Mamadiyev Elyor	
IMPROVING ORGANIZATIONAL AND ECONOMIC MECHANISMS FOR THE ESTABLISHMENT AND DEVELOPMENT OF FAMILY GUEST HOUSES	55
Boynazarov Ulugbek Egamberdievich	
IMPROVING METHODS OF ORGANIZING AND DEVELOPING DOMESTIC TOURISM MARKETS IN UZBEKISTAN	61
Daminov Mirvokhid Isroilovich	
THE IMPACT AND SIGNIFICANCE OF INFRASTRUCTURE IN THE DEVELOPMENT OF THE TOURISM SECTOR.....	67
Dilsora Ibodovna Ibodova	
IMPACT OF STUDENTS AGED OVER 40 ON ECONOMIC ACTIVITY AND BUDGETING BASED ON THE COMPETENCY ECOSYSTEM	74
Nigora Ikrom qizi Primova	
ОЦЕНКА ЭФФЕКТИВНОСТИ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ ХОРЕЗМСКОЙ ОБЛАСТИ: ЭКОНОМЕТРИЧЕСКОЕ МОДЕЛИРОВАНИЕ И СЦЕНАРНОЕ ПРОГНОЗИРОВАНИЕ НА 2026–2030 ГОДЫ	80
Юсупов Шерзодбек Бахтиёр угли	
IMPROVING THE METHODOLOGY FOR ASSESSING THE PROCUREMENT MANAGEMENT SYSTEM IN COMMERCIAL ENTERPRISES	87
Ergashev Jahongir Bakhodirovich	
MULTIVARIATE ECONOMETRIC ANALYSIS OF FACTORS AFFECTING HOUSEHOLD INCOME IN SURXONDARYO REGION	93
Abdunazarova Shahnoza Norquchqor qizi	
СРАВНИТЕЛЬНЫЙ АНАЛИЗ ГОСУДАРСТВЕННЫХ ЦИФРОВЫХ УСЛУГ АЗЕРБАЙДЖАНА И УЗБЕКИСТАНА	99
Юсифов Магамед Исмаил оглу, Гасанли Расул Шахин оглу, Белалова Гузаль Анваровна	
SUSTAINABLE DEVELOPMENT OF THE MINING INDUSTRY IN THE CONTEXT OF THE GREEN ECONOMY.....	105
Xudayberdiyeva Kamila Sadillovna, Fozilova Zumrad Ahmadovna	
IMPROVING THE ECONOMIC EFFICIENCY OF CLOTHING MANUFACTURING ENTERPRISES IN UZBEKISTAN THROUGH DIGITAL TRANSFORMATION	111
Axmedova Gaziza Azim kizi	
КОМПЛЕКСНАЯ ОЦЕНКА ПОТЕНЦИАЛА РЕГИОНАЛЬНОГО АГРОПРОМЫШЛЕННОГО ИНТЕГРИРОВАНИЯ НА ОСНОВЕ МОДЕЛИ АНР-TOPSIS	115
Аликулов А.Б.	
APPLICATION OF CLUSTER METHODS IN THE DEVELOPMENT OF TOURISM INFRASTRUCTURE AND IMPROVEMENT OF ECONOMIC MECHANISMS IN SAMARKAND CITY	121
Tashov Mizrob Maxmudovich	
THE ROLE AND PROSPECTS OF THE GREEN ECONOMY IN THE SERVICE SECTOR.....	130
Musayeva Shoirazimovna, Usmonova Dilfuza Ilkhomovna	
FACTORS AFFECTING THE EFFICIENCY OF REGIONAL ENTERPRISES	135
Nigora Zokirjon qizi Toxirova	
CURRENT STATE OF ATTRACTING INVESTMENTS IN THE DEVELOPMENT OF TOURISM IN THE REGIONS OF UZBEKISTAN AND THE METHODOLOGY OF ECONOMIC EFFICIENCY INDICATORS	142
Temurbek Olimovich Mamayunusov	
PRESUPPOSITION SHIFTS IN CROSS-LINGUISTIC RENDERING OF ANECDOTAL NARRATIVES:	

A COMPARATIVE INQUIRY INTO TRIGGER RETENTION AND TRANSFORMATION	148
Umaraliyeva Dildora Taxirjanovna	
DIGITAL TECHNOLOGIES AND RURAL PUBLIC SERVICE QUALITY: AN EMPIRICAL ECONOMETRIC ANALYSIS	156
Bek Hunsia, Feruza Mansurovna Ollokulova	
COMPREHENSIVE ANALYSIS OF THE IMPACT OF WOMEN'S LABOR ACTIVITY ON THE EFFICIENCY OF THE ECONOMIC SYSTEM	164
Ahrorova Asila Abduaziz qizi	
IMPROVING TAX ADMINISTRATION IN THE ENTREPRENEURIAL ENVIRONMENT	170
Azizbek Khurramov	
FORMATION OF FINANCIAL RESULTS AT MOTOR TRANSPORT ENTERPRISES	180
Shanazarova Nilufar Baratovna	
ARIMA-BASED ANALYSIS OF SMALL BUSINESS ACTIVITY IN THE AGRICULTURAL SECTOR OF SURKHANDARYA REGION	185
Fayziyeva Aziza Azamat qizi	
ASSESSMENT OF AGRARIAN SECTOR EFFICIENCY THROUGH THE SFA MODEL	192
Utanov Bunyod Kuvandikovich	
АКТУАЛЬНЫЕ ВОПРОСЫ УПРАВЛЕНИЯ ГОСУДАРСТВЕННЫМ ВНЕШНИМ ДОЛГОМ	196
Шомуродов Равшан Турсункулович, Жуманазаров Шахобиддин Дилмурод угли	
MODERN METHODOLOGICAL APPROACHES TO MANAGING EDUCATIONAL SERVICES MARKETING IN HIGHER EDUCATION INSTITUTIONS	201
Shamshieva Nargizakhon Nosirkhuja kizi	
FINANCIAL MANAGEMENT OF FOREIGN AND DOMESTIC COTTON GINNING ENTERPRISES: COMPARATIVE ANALYSIS, DIAGNOSTICS, AND IMPROVEMENT DIRECTIONS	208
Orif Jumayevich Murodov	
ANALYSIS OF THE INSTITUTIONAL FOUNDATIONS OF STATE INTERVENTION IN THE PRODUCT QUALITY MANAGEMENT PROCESS IN UZBEKISTAN	219
Atakulov Askad Raimkulovich	
ИНТЕГРИРОВАННАЯ МОДЕЛЬ ФОРМАЛИЗАЦИИ НЕФОРМАЛЬНОЙ ЗАНЯТОСТИ И РАСШИРЕНИЯ СОЦИАЛЬНОЙ ЗАЩИТЫ В АГРАРНЫХ РЕГИОНАХ (НА ПРИМЕРЕ КАШКАДАРЬИНСКОЙ ОБЛАСТИ)	224
Бобоназарова Юлдуз Ботировна	
THE ECONOMIC ESSENCE OF RESOURCE USE EFFICIENCY AND ITS ROLE IN INDUSTRIAL ECONOMICS	229
Baymanova Mavlyuda Djurayevna, Aipova Iroda Ikramovna	
THE ROLE OF ARTIFICIAL INTELLIGENCE IN ECONOMIC DEVELOPMENT: EVIDENCE FROM DEVELOPING COUNTRIES	234
Ismatova Diyora Sirojiddin qizi, Ubaydullayeva Gulchexra Erkabayevna	
ЭКОЛОГИЧЕСКАЯ УСТОЙЧИВОСТЬ И РЕСУРСНАЯ АДАПТИВНОСТЬ ОТРАСЛИ МАШИНОСТРОЕНИЯ В РОССИИ, КИТАЕ, ИНДИИ	239
Викторова Наталья Геннадьевна, Абрамчикова Наталья Викторовна, Ван Байянь	
ENSURING ORGANIZATIONAL AND ECONOMIC MECHANISMS FOR HOUSING STOCK MANAGEMENT	249
Aminova Naima Umar qizi	
STRATEGIC MANAGEMENT FOR ECONOMIC GROWTH: PRACTICAL APPROACHES AND IMPROVEMENTS	253
Baymuradov Shokhruxh Makhmudovich, Dilmurodov Komiljon Ahmad o'g'li	
IMPROVING THE EFFICIENCY OF SMALL ENTERPRISES IN THE SERVICE SECTOR (A CASE STUDY OF TASHKENT REGION)	259

Ashirov Alisher

IMPROVING THE ORGANIZATIONAL AND ECONOMIC MECHANISMS FOR THE TRANSFORMATION OF SERVICE ENTERPRISES IN UZBEKISTAN	264
--	-----

Kurbanova Rahima Jamshedovna

INNOVATIVE IDEAS OF YOUNG ENTREPRENEURS AND INFRASTRUCTURE FACTORS IN THE DEVELOPMENT OF SMALL INNOVATIVE BUSINESSES	270
--	-----

Ergashev Oybek Khaydaralievich

MARKETING CHARACTERISTICS OF POSITIONING ORGANIC DRIED FRUIT PRODUCTS IN INTERNATIONAL MARKETS	274
--	-----

Khidirov Shokhrukh

TYPOLOGIZATION OF THE ECONOMIC POTENTIAL AND DEVELOPMENT CHARACTERISTICS OF THE DISTRICTS OF SURKHANDARYA REGION BASED ON STATISTICAL AND NEURAL NETWORK APPROACHES.....	280
--	-----

Normurodov Asliddin Alijon ugli

THE ROLE OF FOREIGN EXPERIENCE IN ANALYSING THE THEORETICAL FOUNDATIONS OF THE AUDIT OF FINANCIAL LIABILITIES	291
---	-----

Palvanov Xusniddin Bekimmatovich

DIGITAL SKILLS AND LABOUR PRODUCTIVITY: A SCENARIO ANALYSIS BASED ON AN INTEGRATED STATISTICAL MODEL	297
--	-----

Madraimov Xabibulla Madaminovich

АКТУАЛЬНЫЕ ВОПРОСЫ ФОРМИРОВАНИЯ СТРУКТУРЫ АКТИВОВ И ПАССИВОВ ГОСУДАРСТВЕННЫХ БАНКОВ УЗБЕКИСТАНА	303
---	-----

Т.И. Бобакулов

АКТУАЛЬНЫЕ ВОПРОСЫ ФИНАНСИРОВАНИЯ ВНЕШНЕТОРГОВУЮ ДЕЯТЕЛЬНОСТЬ КОМПАНИЙ С ДОКУМЕНТАРНЫМИ АККРЕДИТИВАМИ	308
---	-----

М.Т. Ибодуллаева

ФОРМИРОВАНИЕ ИНТЕГРИРОВАННОГО МЕХАНИЗМА УПРАВЛЕНИЯ ОСНОВНЫМИ СРЕДСТВАМИ В УСЛОВИЯХ ИННОВАЦИОННОЙ ЭКОНОМИКИ	312
--	-----

Мусаева Жамила Кароматовна

ПРОБЛЕМНЫЕ ВОПРОСЫ ОБЕСПЕЧЕНИЯ КОНКУРЕНТОСПОСОБНОСТИ КОММЕРЧЕСКИХ БАНКОВ УЗБЕКИСТАНА	320
--	-----

Ш.Т. Ибодуллаев

THE IMPORTANCE OF STATE SUPPORT AND INVESTMENT POLICY IN ENSURING THE FINANCIAL STABILITY OF MASS MEDIA ENTERPRISES.....	325
--	-----

Sharipova Shahlo Istamovna

CURRENT STATUS AND DEVELOPMENT TRENDS OF MOTOR TRANSPORT SERVICES	329
---	-----

Rakhimov Azamat Hamrakulovich

ПРИМЕНЕНИЕ ЭКСТРЕМАЛЬНЫХ МОДЕЛЕЙ В ОЦЕНКЕ ЭКОНОМИЧЕСКОГО ПОТЕНЦИАЛА ПРЕДПРИЯТИЯ.....	333
--	-----

Мусаева Шоира Азимовна

MULTI-FACTOR ECONOMETRIC MODELS OF WATER RESOURCE USE IN ENSURING REGIONAL ECONOMIC STABILITY	341
---	-----

Xaitbaev Jasurbek Otaxanovich

СОВЕРШЕНСТВОВАНИЕ ПРАКТИКИ ИСПОЛЬЗОВАНИЯ ИНСТРУМЕНТОВ ЭЛЕКТРОННОГО ДОКУМЕНТООБОРОТА В КОММЕРЧЕСКИХ БАНКАХ.....	345
--	-----

Шомуродов Равшан Турсункулович

THE WAYS OF IMPROVING COMPETITIVENESS IN COMPANIES OF THE CONSTRUCTION INDUSTRY	350
---	-----

Buriev Khakim Toshimovich, Usmanov Ilxom Achilovich, Tolibov Abduazim Zoxid ugli

MACROECONOMIC MODELS AND PROSPECTS OF TRANSITION TO A GREEN ECONOMY IN UZBEKISTAN	357
---	-----

Sharipboyev Hasanboy Marks ugli, Sharipov Kuvondik Baxtiyorovich

THE IMPACT OF HRM PRACTICES ON ACADEMIC STAFF WORK EFFICIENCY IN HIGHER EDUCATION INSTITUTIONS.....	366
---	-----

Sultonboyeva Munira Bahodirovna, Sultanova Kamila Muktorali Kizi

THE ECONOMIC ROLE OF RENEWABLE ENERGY SOURCES IN THE DEVELOPMENT OF THE GREEN ECONOMY IN UZBEKISTAN	374
Inatullayeva Intizor Jamshid qizi	
ОЦЕНКА ФИЗИОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ КРУПНОГО РОГАТОГО СКОТА, ЗАВЕЗЁННОГО В РЕСПУБЛИКУ КАРАКАЛПАКСТАН ИЗ-ЗА РУБЕЖА, С ИСПОЛЬЗОВАНИЕМ ЦИФРОВЫХ ТЕХНОЛОГИЙ	378
Аскарова Нилуфар Бахтияровна	
COOPERATIVE MECHANISMS FOR REGIONAL DEVELOPMENT: A FRAMEWORK ANALYSIS OF CULTURAL TOURISM ENTERPRISE PARTNERSHIPS.....	382
Shohruzbek Ruziyev	
IMPROVING THE ECONOMIC EFFICIENCY OF RESOURCE UTILIZATION IN METALLURGICAL ENTERPRISES: INTERNATIONAL EXPERIENCE AND MODERN DEVELOPMENT TRENDS	393
Matkuliev Akbar Karimovich	
TAX INCENTIVES GRANTED TO ENTERPRISES LOCATED IN SPECIAL ECONOMIC ZONES	397
Torayeva Nafisa Odiljonovna	
REQUIREMENTS FOR TRANSITIONING TO ELECTRONIC BUSINESS AND CONDITIONS FOR DIGITALIZATION.....	402
Ismoilov Diyorbek Ismoiljon ugli	
DEVELOPMENT OF ALTERNATIVE ENERGY AS AN IMPORTANT FACTOR IN ENSURING A SUSTAINABLE ECONOMY AND ENERGY SECURITY	407
Ergash Bobobekov	
ANALYSIS OF WAGE DYNAMICS IN THE EXAMPLE OF SURKHANDARYA REGION BASED ON PANEL DATA.....	412
Abdunazarova Shahnoza Norquchqor kizi	
THE ROLE OF MARKETING STRATEGIES IN IMPROVING THE MARKET COMPETITIVENESS OF CARPET INDUSTRY ENTERPRISES	420
Arzieva Sevinch Shomurot kizi	
CONSUMER PROPERTIES OF FOOD PRODUCTS IN UZBEKISTAN: TRADITIONS, TRANSFORMATION AND NEW QUALITY STANDARDS.....	425
Gayrat Pardaev	
DIRECTIONS FOR STIMULATING ECONOMIC GROWTH THROUGH THE IMPROVEMENT OF THE TAX SYSTEM.....	431
Yakhshimuratova Khasiyat Khudaybergenovna	
THE ROLE OF E-COMMERCE IN THE ECONOMY OF UZBEKISTAN AND ITS DEVELOPMENT PROSPECTS	435
Kambaraliyeva Intizor Suxrobovna	
Aliyarov Olim Abdug'aparovich	
ISSUES OF IMPROVING PRE-TRIAL TAX DISPUTE RESOLUTION MECHANISMS BASED ON INTERNATIONAL EXPERIENCE	439
Solihova Xumora Xasan kizi	
INCREASING THE ATTRACTIVENESS OF DIVIDEND POLICY IN UZBEKISTAN COMPANIES.....	446
Akmal Komiljonovich Shermukhamedov	
COMMUNITY-BASED HERITAGE TOURISM MODELS AS A TOOL FOR ENHANCING HANDICRAFT DEVELOPMENT IN UZBEKISTAN	451
Olimjonova Farog'at Dilmurod qizi	
Amiriddinova Muslima Zayniddin qizi	
ИНСТИТУЦИОНАЛЬНЫЕ МЕХАНИЗМЫ СОЦИАЛЬНОЙ ЗАЩИТЫ НАСЕЛЕНИЯ В УСЛОВИЯХ ПЕРЕХОДНОЙ ЭКОНОМИКИ: ОПЫТ РЕСПУБЛИКИ УЗБЕКИСТАН	458
Шоахмедов Шохрух Шорахимович	

OF EFFECTIVE USE OF AGRICULTURAL LAND	464
Umarov Muzaffar Yusupbayevich	
ECONOMIC CONTENT OF INTANGIBLE ASSETS IN THE FIELD OF INFORMATION AND COMMUNICATION TECHNOLOGIES AND SPECIFIC CHARACTERISTICS OF THEIR RECOGNITION	469
Ishankulov Izzatilla Nurillaevich	
DETERMINANTS OF NON-PERFORMING LOANS IN SERVICE SECTOR LENDING AND CREDIT RISK MITIGATION MECHANISMS	473
Nurmukhammedov Abdijabbar Yunusovich	
ESG INTEGRATION PRACTICES INTO CORPORATE CULTURE SYSTEM IN THE JOINTSTOCK SECTOR OF UZBEKISTAN: A CASE STUDY OF “DORI-DARMON” JSC	479
Sadikova Muslima Alisher kizi	
DEVELOPMENT OF THE METAL MARKET IN THE TASHKENT REGION AND WAYS TO IMPROVE IT	485
Musayeva Shoira Azimovna	
SMALL BUSINESS AS A CATALYST FOR REGIONAL ECONOMIC DEVELOPMENT: AN EMPIRICAL ANALYSIS WITH EVIDENCE FROM UZBEKISTAN	491
Jo‘rayev Ilhomjon Kamolidinovich	
ISSUES OF DEVELOPING DEPOSIT OPERATIONS IN COMMERCIAL BANKS	497
Rahimov Akmal Matyaqubovich	
IMPROVING TEXTILE LOGISTICS AND SUPPLY CHAIN MANAGEMENT IN UZBEKISTAN	503
Isroilov Madaminjon Mukhsinovich	
FEATURES OF SUMMARIZING AND EVALUATING THE RESULTS OF FINANCIAL STATEMENT AUDITING IN UZBEKISTAN PRACTICE	509
Isroil Ismoilovich Meliev	
ГОСУДАРСТВЕННОЕ УПРАВЛЕНИЕ ФИНАНСАМИ И СОЦИАЛЬНОЕ РАВЕНСТВО В УЗБЕКИСТАНЕ: ИНТЕГРАЦИЯ МЕТОДОЛОГИИ РЕФА С ДИСТРИБУТИВНЫМ АНАЛИЗОМ НА ОСНОВЕ ПОДХОДА SEQ	516
Зокиржонов Мухаммадсодик Равшанбек угли	
FACTORS AFFECTING DAIRY PRODUCTION EFFICIENCY: CORRELATION AND REGRESSION ANALYSIS	530
Ergashev M.Y.	
Tairova Z.M.	
METHODOLOGICAL FOUNDATIONS OF COST ACCOUNTING AND ANALYSIS IN AQUACULTURE CLUSTERS: IFRS INTEGRATION, ECONOMETRIC MODELING, AND ESG PERSPECTIVES	537
Shodiev Aslam Rahmatilloevich	

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Abstract. The article presents a holistic methodological approach to improving cost accounting and economic analysis in Uzbekistan's fishery clusters. Based on 2019–2024 data from the “O‘zbekbaliqsanoat” Association, the study develops a methodology for adapting IAS 41, IFRS 8, and IFRS 13 to national practice, a multifactor regression model ($R^2 = 0.847$; $F = 18.75$; $DW = 1.92$), and a conceptual ESG reporting system. FCR, feed price, and labour productivity are identified as the dominant cost drivers. Pilot implementation reduced production costs by 8–12%.

Keywords: IAS 41, IFRS 8, aquaculture cluster, cost accounting, biological asset, fair value, multifactor regression, ESG reporting, Uzbekistan.

Аннотация. В статье представлен целостный методологический подход к совершенствованию учёта затрат и экономического анализа в рыболовческих кластерах Узбекистана. На основе данных ассоциации «O‘zbekbaliqsanoat» за 2019–2024 годы разработаны методика адаптации стандартов IAS 41, IFRS 8 и IFRS 13 к национальной практике, многофакторная регрессионная модель ($R^2 = 0,847$; $F = 18,75$; $DW = 1,92$), а также концептуальная система ESG-отчётности. FCR, цена корма и производительность труда определены как доминирующие факторы себестоимости. Апробация в пилотных кластерах позволила снизить себестоимость продукции на 8–12%.

Ключевые слова: IAS 41, IFRS 8, аквакультурный кластер, учёт затрат, биологический актив, справедливая стоимость, многофакторная регрессия, ESG-отчётность, Узбекистан.

INTRODUCTION

The global aquaculture sector has entered a phase of rapid development over the last decade. According to FAO [1], global aquaculture production reached 130.9 million tons in 2022, surpassing capture fisheries for the first time and accounting for 51% of aquatic animal production. This shift is of considerable economic importance and requires the development of systems capable of supporting investment planning, cost control, and sustainable development reporting within the industry.

In Uzbekistan, the growth rate of the fisheries sector is particularly noteworthy. From 2017 to 2024, fish production increased 2.4 times, from 83.9 thousand tons to 199.4 thousand tons, while the number of full-cycle clusters grew from 5 to 13 [16]. Presidential Resolution No. PR-83 of January 13, 2022 [14], and Presidential Decree No. PD-60 of January 28, 2022 [13], set the task of increasing industry production to 700 thousand tons and establishing new clusters.

However, despite the sector's rapid economic development, its cost accounting and analysis methodology remains insufficiently developed in two key respects. First, it does not fully reflect the specific biological and technological nature of the industry. Second, it is not sufficiently aligned with international reporting requirements. In particular, live fish are not recognized as biological assets under IAS 41; fishery clusters lack transfer pricing and segment reporting systems; cost determinants have not been

quantitatively assessed through multifactor analysis; and digitalization and ESG reporting systems have not yet been fully introduced.

The purpose of this article is to develop the methodological foundations of cost accounting and economic analysis in fishery clusters within a unified system and to provide ready-to-use tools for their implementation in national practice.

LITERATURE REVIEW

The conceptual foundations of cost accounting and economic analysis theory were formed in the works of C. Drury [7] and C. T. Horngren, S. M. Datar, and M. V. Rajan [8]. Their studies widely developed the principles of cost classification, selection of costing methods, and efficiency measurement. R. S. Kaplan and R. Cooper [9] developed activity-based costing, offering a methodological solution to the allocation of overhead costs in integrated cluster structures. R. S. Kaplan and D. P. Norton [10] introduced the Balanced Scorecard (BSC) as a strategic management measurement tool. In the post-Soviet school of economics, M. A. Vakhrushina [11] and V. B. Ivashkevich [12] adapted these methods to enterprise practice.

Scientific debate on the accounting of biological assets has continued since 2000, when IAS 41 was adopted [20]. Argilés and Siof [2] empirically proved that fair value enhances the quality of farm financial reporting, while Argilés et al. [3] showed that fair value-based valuation improves the accuracy of future cash flow forecasts. From a critical perspective, Elad [4] and Herbohn [5] raised the issue of the reliability of fair value in the absence of active markets. In a joint study, Elad and Herbohn [6] also noted that implementation challenges in transition economies have not yet been fully resolved.

In the field of ESG and sustainability reporting, the GRI [24] and SASB frameworks are widely used in international practice. The ISSB's IFRS S1 standard [23] represents an important step toward consolidating these approaches into a single global baseline. The introduction of ESG indicators for aquaculture, which is directly dependent on the aquatic environment, is recognized as a necessary condition for attracting investment and ensuring export competitiveness.

In local literature, A. I. Alikulov [18] conducted research dedicated to improving cost accounting in fishery clusters. A. R. Shodiev [17] studied the methodological problems of implementing IAS 41 in the fisheries sector and, in a subsequent article [19], presented an econometric analysis of fish production cost determinants. G. V. Savitskaya's methodology for analyzing economic activity [25] includes analytical methods that can also be applied to the fisheries sector.

Overall, the literature review shows that the integration of recognition under IAS 41, cluster management accounting, econometric cost analysis, and ESG reporting within a single methodological framework has not yet been sufficiently studied from a scientific standpoint, especially in the context of Uzbekistan, where national standards and IFRS coexist. This study is intended to fill this research gap.

RESEARCH METHODOLOGY

The empirical basis of the study consists of the 2019–2024 financial statements of full-cycle clusters within the “O‘zbekbaliqsanoat” Association [16]. A full-cycle cluster is defined as an enterprise that integrates hatchery operations, fry rearing, commercial fish production, processing, and trade stages. Primary data were obtained from the official accounting documents of the clusters, while secondary data were sourced from official publications of the Statistics Agency and reports of the association.

The methodological toolkit includes a dialectical and systems approach, monographic observation, document analysis, comparative analysis of national accounting standards and IFRS, statistical grouping, the balance method, and SWOT analysis. BSC and KPI systems were used to measure efficiency. Econometric calculations were performed using SPSS Statistics 27 and EViews 12 software packages.

The research process consists of three stages. At the first stage, the current state of cost accounting in clusters was studied using the monographic method, and systemic problems were identified. At the second stage, improved accounting tools, including primary documents, a chart of accounts, and an IAS 41-based methodology, were developed and tested in cluster operations. At the third stage, the quantitative determinants of cost were identified using econometric methods, and the results were transformed into forecast scenarios.

A multiple linear regression model was applied in the econometric specification [7]:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_9 X_9 + \varepsilon$$

where Y denotes unit cost, measured in UZS/kg, and $X_1 \dots X_9$ denote the explanatory variables presented in Table 1. The model was estimated based on 42 observations for the period 2019–2024. The coefficient of determination (R^2), F-statistic, and Durbin–Watson (DW) statistic were used for model diagnostics.

ANALYSIS AND RESULTS

During the research process, the main factors directly influencing the formation of production costs in aquaculture clusters were identified and included in the econometric model as explanatory variables. These factors reflect the biological, technological, and economic characteristics of the fish farming process. Specifically, the feed conversion ratio, feed price, electricity consumption, labour productivity, pond productivity, survival rate, rearing period, fish species, and technology type were selected as the key factors for assessing cost dynamics. The content of these variables and their expected direction of impact are presented in Table 1.

Table 1
Explanatory Variables of the Regression Model

Var.	Description	Expected Direction of Impact
X1	FCR — kg feed / kg growth	+
X2	Feed price — price of compound feed	+
X3	Electricity consumption — for aeration and water circulation	+
X4	Labor productivity — output per employee	–
X5	Pond productivity — output per unit area	–
X6	Survival rate — proportion surviving until harvest	–
X7	Rearing period — cycle duration (months)	+
X8	Fish species — species being farmed (categorical)	±
X9	Technology type — extensive/semi-intensive/intensive	±

Source: Developed by the author based on industry characteristics and literature.

The variables presented in Table 1 reflect two key economic principles of the industry. The first principle is that feed-related variables (X_1 and X_2) have a positive expected sign: as feed consumption and feed price increase, production cost also increases. This is an expected result, since feed occupies a dominant position in the cost structure of fish farming. The second principle is that efficiency indicators (X_4 , X_5 , and X_6) have a negative expected sign: well-organized and highly productive production reduces unit costs. The categorical variables X_8 and X_9 control for differences in fish species and production technology.

Industry Characteristics and Improved Cost Classification. Fish production has four important features that distinguish it from other industries: (1) value is created continuously throughout the process of biological transformation, rather than at a single point in production; (2) due to seasonality, costs and revenues are concentrated in specific periods; (3) as of the reporting date, there is a substantial volume of work in progress in the form of immature biomass; and (4) the multi-stage chain from hatchery to market requires internal transfer operations. The share of feed, which accounts for 50–65% of production cost, forms the core of the industry's economics.

In addition to the current national classification, three new cost items are proposed: depreciation of artificial basins to reflect capital-intensive infrastructure, security costs to account for the risk of theft of live stock, and environmental costs to reflect increasing conservation obligations in aquaculture. Eight new primary document forms have also been developed, including a fry purchase act, a basin stocking act, and a daily feed consumption report. Simple and stepwise methods are proposed as the primary costing methods, while functional cost analysis is identified as a promising prospective method.

Recognition and Measurement of Biological Assets under IAS 41. Under the current National Accounting Standards (NAS), live fish are recorded as work in progress based on historical cost. This study develops a methodology for recognizing live fish, fry, and incubation products as biological assets and measuring them at fair value in accordance with the three-level hierarchy of IFRS 13 [22]: Level 1 — prices in an active market; Level 2 — prices for similar assets; and Level 3 — DCF models for species without an active market.

For operational implementation, an expanded chart of accounts covering 19 business transactions was developed. For the first time in the national context, special accounts 0270 “Biological Assets” and 9050 “Income from Biological Transformation” are proposed. Analytical accounting is maintained in three dimensions: basin, season, and product type. The improved calculation formula is as follows:

$$\text{Cost} = \text{FV}_0 + \text{PEX} \mp \text{Result of BT} - \text{By-product}$$

where FV_0 denotes the fair value at the beginning of the period; PEX denotes production expenses for the period; and Result of BT denotes the gain or loss from biological transformation.

A sample calculation shows that, with an FCR of 1.8, 1,500 kg of fry grew into 4,000 kg of marketable fish. Under the traditional method, biomass is valued at accumulated cost, whereas under IAS 41 it is measured at fair value at each reporting date. This approach discloses the economic result of biological growth. This finding is consistent with the conclusions of Argilés et al. [3], while the reliability issue raised by Elad [4] and Herbohn [5] is practically addressed by prioritizing cost and income approaches when an active market is absent.

Management Accounting System. Three main elements of the cluster management accounting system have been designed. The first is a model accounting policy that defines the basis for recognizing and measuring biological assets, the costing method used at each stage, transfer pricing rules, the structure of analytical accounts, and the form of segment reporting. The second is a transfer pricing methodology: the market price method is used when an active market exists, while the cost-plus method with a 15–25% margin is applied when no active market is available. This range is consistent with the median indicators recommended in the OECD Guidelines [12]. The third is a segment reporting form for five operating segments — incubation, fry production, commercial fish farming, processing, and sales — in accordance with IFRS 8 [21]. The three-year tax incentive granted to clusters under Presidential Decree PD-4005 is reflected separately in the segment report.

Table 2 presents the diagnostic indicators of the regression model.

Table 2
Quality Indicators of the Regression Model (n = 42; 2019–2024)

Indicator	Value	Economic Interpretation
Coefficient of Determination R ²	0.847	The model explains 84.7% of the variance in cost price.
Adjusted R ²	0.779	An indicator that takes the number of variables into account.
Fisher's F-criterion	18.75 (p < 0.001)	The model is statistically significant overall.
Durbin–Watson (DW)	1.92	No autocorrelation of residuals (norm: 1.5–2.5).
Number of observations	42	5 clusters × 6 years = 30; with additional observations, 42.

Source: Author's calculations based on SPSS Statistics 27 results.

The data presented in Table 2 allow several important conclusions to be drawn. The coefficient of determination, $R^2 = 0.847$, is a high indicator for economic research, indicating that the nine factors included in the model explain 84.7% of the variation in production cost. The adjusted coefficient of determination, $\text{Adj. } R^2 = 0.779$, confirms the substantial explanatory power of the model after accounting for the number of variables included, thereby indicating that the model does not suffer from overfitting. The F-statistic, $F = 18.75$ ($p < 0.001$), confirms the overall statistical significance of the model. The Durbin–Watson statistic, $DW = 1.92$, which is close to 2, indicates the absence of serious autocorrelation among the residuals and confirms the suitability of the model for short-term forecasting.

The results also show that FCR (X_1) and feed price (X_2) have the strongest positive impact on production cost, while labour productivity (X_4) has a statistically significant negative effect. These findings confirm the central role of feed-related costs and labour efficiency in the economics of the aquaculture sector.

Table 3 presents a quantitative assessment of the potential for reducing production costs.

Table 3
Potential for Cost Reduction Based on the Regression Model

Strategic Measure	Reduction Potential	Related Factor
Improving feed conversion ratio (lowering FCR)	8–12%	X1 — FCR
Vertical integration of the value chain	15–20%	X2 — Feed price
Introducing intensive technologies	8–15%	X9 — Technology
Increasing labor productivity	12–15%	X4 — Labor
Synergistic effect of the four measures	30–45%	Combined

Source: Author's calculations based on regression model coefficients.

Table 3 illustrates the practical application of the regression model. Each strategic measure is directly linked to a specific factor in the model. For example, reducing the FCR by 0.1 units decreases production cost by a calculable amount through the β_1 coefficient. Vertical integration through the establishment of in-house compound feed mills reduces the purchase price of feed, which is reflected through X_2 . Intensive technologies are represented by the categorical variable X_9 , and the model indicates a significant reduction in production cost when these technologies are implemented. The most important conclusion of the table is the synergistic effect shown in the final row: when the four initiatives are implemented together, they generate an efficiency effect of 30–45%, which exceeds the simple sum of their individual effects.

Digitalization and ESG Reporting. The conceptual model for digitalization consists of three layers. The first is the operational layer, in which ERP systems, such as 1C, SAP Business One, and Microsoft Dynamics 365, automate accounting documents. The second is the monitoring layer, in which IoT sensors measuring water temperature, dissolved oxygen, and automatic feed distribution monitor pond processes in real time. This significantly simplifies FCR control. The third is the analytical layer, in which Power BI and Tableau tools are used to visualize data, while artificial intelligence algorithms support early disease detection and optimization of feeding rates.

A system of ten KPIs was developed across four dimensions to measure efficiency: production efficiency, including FCR and output per cubic meter; economic efficiency, including cost per kilogram and return on biological assets; labour productivity, including output per employee; and resource consumption, including water and energy consumption per ton. These indicators were incorporated into a Balanced Scorecard (BSC) system, which was expanded with a fifth perspective: sustainable development and ESG [10].

The conceptual model for ESG reporting includes environmental, social, and governance dimensions. The environmental dimension covers water resources, energy use, and CO₂ emissions. The social dimension includes employment, occupational safety, and relations with local communities. The governance dimension includes internal control, transparency, and accountability. The model is aligned with GRI [24], SASB, and ISSB standards, including IFRS S1 [23].

Table 4 presents the expected economic benefits from implementation in the pilot clusters.

Table 4
Expected Economic Benefits from Implementing the Approach

Benefit Area	Quantitative Indicator	Key Mechanism
Reduction in production cost	8–12%	FCR + vertical integration
Reduction in production losses	15–20%	IoT monitoring + intensive technology
Acceleration of management decision-making	30–40%	ERP + real-time data
Increased attractiveness for foreign investors	20–30%	IFRS compliance + ESG
Expansion of export potential	15–25%	GRI/SASB/ISSB reporting

Source: Compiled by the author based on research and the practices of pilot clusters.

Table 4 illustrates two categories of economic effects resulting from the proposed approach. The first category consists of direct cost-related effects: an 8–12% reduction in production costs and a 15–20% decrease in losses may be achieved through increased operational efficiency. The second category includes strategic financial effects: a 20–30% increase in attractiveness for foreign investors and a 15–25% rise in export potential may result from the transition to IFRS-based reporting and the implementation of an ESG system.

Furthermore, management decision-making may be accelerated by 30–40% due to the integration of ERP and IoT technologies. It should be noted that these figures are approximate estimates based on previous studies and the practices of pilot clusters; future empirical research will allow these estimates to be refined.

CONCLUSION AND RECOMMENDATIONS

In this study, a unified methodological framework for cost accounting and economic analysis in Uzbekistan's fishery clusters was developed. The regression model presented in Table 2 demonstrated high statistical reliability ($R^2 = 0.847$; $F = 18.75$; $DW = 1.92$), while Table 3 identified specific cost-reduction reserves for each factor. The effects presented in Table 4 cover two categories: operational effects, related to production cost reduction, and strategic effects, related to investment attractiveness and export potential. The results are reflected in a Scopus-indexed article [17] and in other publications.

Based on the research findings, the following conclusions were drawn:

Three new industry-specific cost items and eight primary document forms have been proposed. They form the informational foundation for the IAS 41 valuation methodology and multifactor econometric analysis, since neither can function fully without the other.

An expanded chart of accounts covering 19 business transactions and incorporating accounts 0270 and 9050 reveals the economic substance of biological transformation in financial reporting. The reliability issue raised by Elad [4] and Herbohn [5] is addressed by prioritizing cost and income approaches in the absence of an active market.

The multifactor regression model identified FCR, feed price, and labour productivity as the dominant cost factors. Three scenarios — pessimistic, baseline, and optimistic — create a quantitative basis for budgeting and investment planning in cluster management.

The conceptual ESG reporting model has been aligned with GRI [24], SASB, and ISSB standards, including IFRS S1 [23]. A fifth perspective — sustainable development and ESG — has been added to the Balanced Scorecard, ensuring a balance between financial and environmental objectives.

Based on the above conclusions, the following scientific and practical recommendations are proposed:

First, the “O‘zbekbaliqsanoat” Association and the Ministry of Economy and Finance should jointly approve a special model accounting policy for the fishery industry based on the requirements of IAS 41 and IFRS 8, and develop methodological guidelines regulating its implementation in clusters.

Second, a phased programme should be introduced in full-cycle clusters to reduce the FCR, vertically integrate feed supply, and implement intensive technologies synergistically. This may ensure a 30–45% reduction in total costs over a three-year period.

Third, a digital monitoring system should be introduced to track basin conditions and feed consumption in real time through the integration of IoT sensors and ERP systems. This will simultaneously improve management decision-making efficiency and FCR control.

Fourth, an annual ESG reporting system should be implemented in accordance with GRI, SASB, and ISSB standards, including IFRS S1, and integrated with segment financial reporting. This will provide the transparency required by foreign investors and export markets.

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