

## CHAPTER «AGRICULTURAL SCIENCES»

### INNOVATIVE APPROACHES TO SUSTAINABLE DEVELOPMENT OF FISHERIES IN UKRAINE: TECHNOLOGY, ECOLOGY, AND MARKETING

Maryna Burhaz<sup>1</sup>

DOI: <https://doi.org/10.30525/978-9934-26-602-7-4>

**Abstract.** The sustainable development of aquaculture in Ukraine is considered a key factor in ensuring food security, biodiversity conservation, and the competitiveness of the agricultural sector. Under conditions of climate change, increasing anthropogenic pressure on aquatic ecosystems, and the globalization of food markets, traditional extensive fish farming models are losing effectiveness. This research focuses on identifying innovative solutions that integrate technical modernization, ecological responsibility, and modern marketing strategies [8]. The study emphasizes three interrelated areas: (1) technical innovations, including recirculating aquaculture systems (RAS), automation, and selective breeding programs [2]; (2) ecological innovations, such as integrated multi-trophic aquaculture (IMTA), water quality management, and the use of renewable energy [6]; and (3) marketing innovations, including eco-labeling, branding, digitalization, and producer cooperation for international market expansion [4].

A systemic and interdisciplinary approach was applied. The methodology combines analysis and synthesis of scientific literature, comparative analysis of international experience, SWOT analysis of innovative technologies in aquaculture, and case study elements to examine practical examples of modern technology implementation. This approach provides a comprehensive assessment and allows for a comparison of Ukrainian

---

<sup>1</sup> I.I. Mechnikov Odesa National University, Ukraine  
ORCID: <https://orcid.org/0000-0003-1551-6002>

practices with leading global countries, including Norway, China, EU member states, the United States, and Iceland.

The aim of the study is to define and scientifically substantiate innovative approaches to the sustainable development of fisheries in Ukraine, taking into account technical, ecological, and marketing aspects. The study seeks to provide recommendations for integrating these approaches into the national aquaculture development strategy and adapting the Ukrainian sector to global standards.

The findings indicate that technical innovations such as RAS, automated monitoring, and digital management tools significantly increase productivity and reduce environmental risks. However, in Ukraine, their application remains limited and mostly implemented as pilot projects, while in leading countries they are already standard practice. Ecological innovations, including IMTA, biopreparations, and renewable energy, provide a balance between economic activity and environmental protection. Global experience (Norway, Canada, EU) confirms their effectiveness, yet in Ukraine their adoption remains fragmented. The marketing dimension highlights the importance of developing the brand “ecologically clean Ukrainian fish,” expanding digital sales channels, implementing international certification standards, and introducing innovative packaging. A comparison with global practices demonstrates that Ukraine lags significantly behind in ecological certification and market digitalization, which decreases the international competitiveness of its products.

The results confirm that comprehensive modernization of Ukrainian aquaculture is possible only through the combination of three components: technical innovations, ecological responsibility, and modern marketing strategies. The synergy of science, entrepreneurship, and state regulation is the decisive factor for Ukraine’s successful integration into the global fish product market. Future research should focus on the adaptation of European “green aquaculture” standards, the development of national IMTA support programs, the application of digital technologies based on Big Data and IoT, and the analysis of global marketing trends. Such steps will enhance the competitiveness of the Ukrainian aquaculture sector and promote its sustainable development.

## 1. Introduction

The sustainable development of fisheries is one of the key directions for ensuring food security, biodiversity conservation, and enhancing the competitiveness of Ukraine's agricultural sector. Under the conditions of climate change, increasing anthropogenic pressure on aquatic ecosystems, and the globalization of food markets, traditional models of fisheries management are losing their effectiveness [8]. This necessitates the search for and implementation of innovative solutions that combine technological advancements, ecological approaches, and modern marketing strategies [1].

The relevance of the topic lies in the fact that aquaculture in Ukraine [7] has significant development potential but faces a number of challenges: outdated material and technical infrastructure, lack of high-quality feed, low level of integration of modern biotechnologies, underdeveloped systems for monitoring the state of water resources, as well as insufficient consumer-oriented strategies. Innovative approaches can overcome these barriers and ensure the transition of the sector from an extensive model to an intensive one, based on the principles of ecological responsibility and market adaptability.

The novelty of the study is determined by its comprehensive approach to analyzing current trends in fisheries, where three interrelated components are considered simultaneously: technical innovations (recirculating aquaculture systems, automation, selection and biotechnologies), ecological solutions (integrated multi-trophic aquaculture systems, restoration of aquatic ecosystems, water quality management), and marketing strategies (branding, certification, digital traceability, and the development of niche markets). Such an approach makes it possible not only to assess the current state but also to determine the optimal directions for the transformation of Ukrainian fisheries in the context of European and global trends.

The aim of the study is to identify and substantiate innovative approaches to the sustainable development of fisheries in Ukraine, taking into account technical, ecological, and marketing factors.

To achieve this aim, the following objectives have been set: to investigate modern technical solutions and technologies that increase efficiency and resource conservation in aquaculture; to analyze ecological approaches aimed at minimizing the negative impact of fisheries activities on the environment and preserving biodiversity; to identify key marketing innovations that

ensure the competitiveness of Ukrainian fish products on domestic and international markets; and to propose practical recommendations for integrating technical, ecological, and marketing solutions into strategies for the sustainable development of fisheries in Ukraine.

The research methodology is based on a combination of systemic and interdisciplinary approaches. Methods of analysis and synthesis of scientific literature, comparative analysis of international experience, SWOT analysis of innovative aquaculture technologies, and case study elements for examining practical examples of innovation implementation were applied.

### **2. Technical Innovations in the Sustainable Development of Fisheries**

The development of fisheries in Ukraine largely depends on the implementation of modern technological solutions that increase production efficiency while ensuring ecological balance. In this context, it is important to take into account both global trends and the local specificities of domestic aquatic ecosystems and market infrastructure [2]. Technological progress in fisheries includes the modernization of equipment for fish farming, the use of advanced feeding systems, optimization of water circulation and biofiltration, and the introduction of automated monitoring systems. Considering the significant potential of its inland waters, Ukraine is gradually integrating these technologies, which allows for higher profitability and reduced negative environmental impacts.

Modern innovative approaches to the technical support of fish farms can be divided into three main groups: intensive farming technologies, automated control systems, and intelligent resource management solutions. For example, recirculating aquaculture systems (RAS) make it possible to maintain stable water parameters while reducing dependence on natural water resources [2]. This is especially relevant for regions with limited access to high-quality water. The use of sensors for oxygen, temperature, and pH levels enables the optimization of fish habitat conditions, reducing the risk of disease and increasing biomass growth.

At the same time, fisheries in Ukraine largely retain an extensive character, resulting in lower productivity compared to European countries [1]. To better understand the specific features, it is useful to examine the main directions of innovation in the technical and technological sphere of fisheries (Table 1).

Table 1

**Comparison of Traditional and Innovative Fisheries Technologies**

| Criterion            | Traditional Technologies                       | Innovative Technologies (RAS, Biofilters, Automation) |
|----------------------|------------------------------------------------|-------------------------------------------------------|
| Water source         | Natural water bodies                           | Closed systems, controlled water recirculation        |
| Productivity         | 0.5–1.5 t/ha                                   | 50–150 kg/m <sup>3</sup> in RAS                       |
| Feed usage           | Natural or compound feeds without optimization | High-protein feeds, automated feeding                 |
| Parameter control    | Manual, occasional                             | Automated, continuous                                 |
| Environmental impact | High load on water bodies                      | Pollution minimized due to closed-loop systems        |

It is also worth emphasizing the innovative approaches to fish feeding. The improvement of feed formulas makes it possible to reduce production costs and accelerate fish growth rates. In Ukraine, feeds with a balanced content of proteins, fats, and carbohydrates adapted to the nutritional needs of carp and salmonid species are being actively tested. The use of automated feeding systems ensures the even distribution of feed in water bodies, which increases the feed conversion ratio (Table 2).

Table 2

**Modern Types of Fish Feeds and Their Characteristics**

| Feed type               | Protein content (%)    | Application features                           | Expected weight gain      |
|-------------------------|------------------------|------------------------------------------------|---------------------------|
| Extruded compound feeds | 35–40                  | Increased buoyancy, high digestibility         | +25–30%                   |
| Pelleted feeds          | 28–32                  | For carp farms                                 | +15–20%                   |
| Specialized feeds       | 40–45                  | For salmonid species, intensive systems        | +30–35%                   |
| Biological additives    | 10–15 (in composition) | Probiotics, enzymes, immune system stimulators | Reduced disease incidence |

Innovative technical solutions also concern energy efficiency. The use of solar panels, biogas plants, and other alternative energy sources to power pumps and aeration systems helps reduce production costs. The implementation of such technologies is strategically important given the general trends of rising energy costs and the need to reduce the carbon footprint of aquaculture.

In modern conditions, the digitalization of production processes is becoming increasingly relevant. The use of mobile applications and specialized software for monitoring makes it possible to control production parameters in real time. This reduces losses and optimizes feed and energy consumption. Table 3 summarizes examples of digital innovations in aquaculture.

Table 3

**Digital Innovations in Aquaculture**

| <b>Technology</b>         | <b>Purpose</b>                             | <b>Example of implementation</b>  |
|---------------------------|--------------------------------------------|-----------------------------------|
| IoT sensors               | Monitoring temperature, oxygen, pH         | Smart ponds                       |
| Mobile applications       | Monitoring feeding and fish growth         | Remote farm management            |
| Big Data and analytics    | Forecasting growth and diseases            | Optimization algorithms           |
| Drones and aerial imaging | Assessment of pond conditions and biomass  | Visual monitoring of water bodies |
| CRM systems for sales     | Management of sales and customer relations | Farm-to-market integration        |

Thus, innovations in the technical support of Ukrainian aquaculture are aimed at increasing production efficiency, reducing costs, improving environmental parameters, and integrating digital technologies [9]. At the same time, the widespread adoption of such solutions requires state support, access to credit resources, and the training of qualified personnel capable of working with new technologies. The transition from extensive to intensive systems requires both investments and a comprehensive national aquaculture development strategy.

When comparing Ukraine with the world's leading countries, it should be noted that in Norway, China, the EU, and the USA [1], innovations such as recirculating aquaculture systems (RAS) [2], intensive cage farming, automated water parameter monitoring systems, and digital management tools have already become standard practice. In Norway, productivity reaches 100–150 kg/m<sup>3</sup> [3], while in Ukraine pond aquaculture provides only 0.5–1.5 t/ha. In China, aquaculture is supported at the state level with an emphasis on breeding centers and the widespread use of automated feeding, whereas in Ukraine selective breeding programs remain limited

[2]. In the USA, digitalization dominates, with Big Data, IoT, and artificial intelligence applied to predict disease outbreaks and optimize feeding. The EU focuses on “green” technologies, renewable energy, and production transparency through blockchain technologies (Table 4).

Table 4

**Comparison of the Level of Implementation of Technical Innovations in Fisheries (Ukraine vs. Leading Countries of the World)**

| Country                            | Main technologies                                                       | Productivity level                                               | Use of digital solutions                            | Energy efficiency                                          | Status in Ukraine compared to leaders                           |
|------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------|
| <b>Ukraine</b>                     | Pond aquaculture, partial use of RAS, manual parameter control          | 0.5–1.5 t/ha (ponds), up to 30–40 kg/m <sup>3</sup> in pilot RAS | Limited use of sensors and mobile applications      | Only isolated projects with solar panels and biogas plants | Lagging 10–15 years behind leaders                              |
| <b>Norway</b>                      | Marine cage complexes, intensive RAS, automated systems                 | 100–150 kg/m <sup>3</sup> in RAS                                 | Full automation of monitoring, IoT, AI              | Use of renewable energy, CO <sub>2</sub> minimization      | Significantly higher level of technology integration            |
| <b>China</b>                       | Large-scale implementation of RAS, automated feeding, hybrid breeding   | Produces over 60% of global aquaculture                          | Developed digital control system                    | National energy-saving programs                            | Ukraine is only testing approaches that are widespread in China |
| <b>EU (Denmark, Spain, France)</b> | Intensive systems with “green” orientation, combined RAS and cage farms | 70–120 kg/m <sup>3</sup>                                         | Big Data, blockchain for traceability               | Widespread use of solar panels and bioenergy               | Ukraine lacks systemic support for “green aquaculture”          |
| <b>USA</b>                         | Digital farms with AI and Big Data, mobile farm management apps         | 80–100 kg/m <sup>3</sup>                                         | Full integration of IoT, CRM, predictive algorithms | Alternative energy in large-scale farms                    | Ukraine does not yet have systemic digitalization               |
| <b>Iceland</b>                     | Automated complexes, breeding, genetics                                 | Over 100 kg/m <sup>3</sup> , high population resilience          | Robotic systems                                     | Renewable energy (geothermal, hydro)                       | Ukraine is only developing breeding programs                    |

Ukraine is currently at a transitional stage: from traditional extensive technologies to intensive systems with partial use of digital tools. To reach the international level, large-scale investments, state support, training of specialists, and the creation of a national strategy for the development of “smart aquaculture” are required.

### 3. Ecological Innovations in Fisheries

The ecological dimension of fisheries development in Ukraine is a key factor in ensuring its sustainability, since excessive intensification without considering environmental approaches may lead to the degradation of aquatic ecosystems [6]. Modern innovations in aquaculture are aimed not only at increasing productivity but also at reducing negative environmental impacts. Such innovations include recirculating aquaculture systems (RAS), biofiltration, integrated multi-trophic aquaculture (IMTA), the use of biopreparations instead of antibiotics, and energy-efficient aeration technologies [4]. These solutions help reduce pollutant discharges into water bodies, decrease freshwater consumption, and optimize biodiversity.

Contemporary Ukrainian fisheries face challenges such as eutrophication of water bodies, excessive accumulation of organic matter, and an increased risk of fish diseases. One of the promising directions for solving these problems is the introduction of integrated systems where different aquatic organisms use each other’s metabolic products, forming a closed ecological cycle. For example, feed residues and fish metabolic waste can be used to support the growth of algae or invertebrates. This approach helps reduce water pollution levels while simultaneously providing additional products (Table 4).

An important aspect of the ecological modernization of aquaculture is the preservation of biodiversity. The reliance on only a few main fish species in industrial farming creates a risk of genetic degradation and a decrease in the adaptive potential of populations. Therefore, in recent years, Ukraine has been actively exploring the possibility of expanding the range of cultured species, including not only traditional carp but also promising sturgeon, catfish, and trout species. This approach makes it possible not only to diversify production but also to reduce ecological pressure through the combination of different trophic levels in aquatic ecosystems. Table 5 presents examples of integrated ecological systems in aquaculture.

Table 4

**Environmental Problems and Innovative Solutions in Aquaculture**

| Problem                                          | Consequences                     | Innovative solution                     |
|--------------------------------------------------|----------------------------------|-----------------------------------------|
| Eutrophication of water bodies                   | Oxygen depletion, fish mortality | Biofilters, IMTA, feeding control       |
| Accumulation of organic matter in ponds          | Deterioration of water quality   | Biopreparations for waste decomposition |
| Use of antibiotics                               | Microflora resistance            | Probiotics, phytopreparations           |
| High water consumption                           | Resource depletion               | RAS, water recirculation systems        |
| CO <sub>2</sub> emissions and energy consumption | Increased “carbon footprint”     | Solar panels, energy-efficient aerators |

Table 5

**Integrated Ecological Systems in Aquaculture**

| Type of system                              | Components                      | Ecological effect                                 |
|---------------------------------------------|---------------------------------|---------------------------------------------------|
| Fish–algae system                           | Carp + Spirulina                | Water purification, additional bioproduct         |
| Fish–invertebrate system                    | Tilapia + mollusks              | Organic matter utilization, improved transparency |
| IMTA (Integrated Multi-Trophic Aquaculture) | Salmonids + algae + mussels     | Closed nutrient cycle, waste reduction            |
| Pond polyculture                            | Carp + grass carp + silver carp | Biological regulation of phytoplankton            |

Special attention should be paid to the application of biotechnologies in aquaculture. The use of probiotics and enzymes in fish feeding not only increases the efficiency of feed utilization but also reduces the risks of infectious diseases. This is important from the perspective of environmental safety, as it decreases the need for chemical substances that may enter the environment. Biopreparations contribute to the formation of stable microflora in water bodies, which helps stabilize ecosystem processes.

Another promising direction is the energy greening of fish farms. The use of solar panels to power aerators and pumping stations, as well as biogas plants for the utilization of organic waste, helps reduce dependence on fossil fuels. Such solutions not only lower production costs but also promote the transition of aquaculture towards a “green economy” model (Table 6).

**Ecological Innovations in Aquaculture  
and Their Potential for Ukraine**

| <b>Technology</b>                     | <b>Purpose</b>                   | <b>Potential effect for Ukraine</b>           |
|---------------------------------------|----------------------------------|-----------------------------------------------|
| Solar panels                          | Powering pumps, aerators         | Reducing energy costs by 20–30%               |
| Biogas plants                         | Waste utilization                | Energy production and organic fertilizers     |
| Phytopreparations in feeding          | Substitution of antibiotics      | Reduction of water pollution                  |
| Use of biofiltering aquatic organisms | Organic matter removal           | Restoration of water transparency and quality |
| Polyculture farming                   | Biological control of ecosystems | Preservation of biodiversity                  |

Thus, ecological innovations in Ukrainian aquaculture represent an important component of the sector's sustainable development [8]. They combine technological solutions with nature-based approaches, which makes it possible to simultaneously increase the economic efficiency of production and ensure the restoration and preservation of water resources. The further development of these approaches should be based on the integration of scientific research, state support, and practical initiatives of aquaculture enterprises.

When comparing Ukrainian ecological innovations in aquaculture with international experience, it should be noted that Norway and Canada actively apply IMTA, which allows for the simultaneous cultivation of salmonids, algae, and mussels while minimizing organic discharges [1]. China emphasizes polycultural systems (carp, silver carp, grass carp), which naturally regulate ecosystem balance [7]. In EU countries (e.g., Denmark, the Netherlands), biogas plants for the utilization of organic waste and energy generation are being widely implemented [1]. The United States has developed large-scale programs to replace antibiotics with probiotics and phytopreparations, significantly reducing the risks of microbial resistance.

In Ukraine, ecological innovations are mainly introduced locally, in the form of separate projects [9]. Polyculture is relatively widespread, but IMTA and energy greening are still at an early stage (Table 7).

Table 7

**Comparison of Ecological Innovations in Aquaculture  
(Ukraine vs. Leading Countries Worldwide)**

| Country                          | Main ecological technologies                                                           | Environmental effect                                           | Level of implementation | Status in Ukraine compared to leaders        |
|----------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------|----------------------------------------------|
| <b>Ukraine</b>                   | Polyculture (carp, grass carp, silver carp), limited use of RAS, isolated solar panels | Reduction of phytoplankton, partial decrease of organic matter | Local initiatives       | Lagging in IMTA and bioenergy implementation |
| <b>Norway</b>                    | IMTA: salmon + algae + mollusks                                                        | Closed ecological cycles, reduced pollution                    | Widely applied          | Ukraine has no large-scale IMTA yet          |
| <b>Canada</b>                    | Integrated aquaculture, biofiltration                                                  | High water quality, biodiversity conservation                  | National strategy       | No systemic state policy in Ukraine          |
| <b>China</b>                     | Polyculture systems, biopreparations, biofilters                                       | Ecosystem biological control, reduced antibiotics              | Mass application        | Ukraine is only testing biopreparations      |
| <b>EU (Denmark, Netherlands)</b> | Biogas plants, solar energy, phytopreparations                                         | Reduced CO <sub>2</sub> , waste utilization                    | Systemic implementation | Only isolated pilot projects in Ukraine      |
| <b>USA</b>                       | Probiotics, phytopreparations, digital water quality monitoring                        | Reduced resistance, ecosystem stabilization                    | Widely applied          | Limited use of probiotics in Ukraine         |

Thus, ecological innovations are the key to Ukraine's transition towards "green aquaculture." A comparison with leading countries shows that Ukraine has significant potential for the implementation of IMTA, renewable energy sources, and biotechnologies; however, without systematic state support and financing, these processes remain fragmented.

#### **4. Marketing and Development of the Fish Products Market**

Marketing in the Ukrainian aquaculture sector is gradually transforming in response to the challenges of the modern market, which include increasing

competition, changing consumer preferences, and globalization processes [4]. The traditional sales model, which was mainly oriented towards local markets and wholesale intermediaries, no longer meets today's requirements. Modern innovative approaches to marketing in aquaculture combine digital tools, ecological product positioning, branding, and the development of cooperative models to enter international markets.

One of the key trends is the creation of a brand of “environmentally friendly products.” Consumers are showing increasing interest in fish grown without antibiotics in recirculating aquaculture systems, which guarantees safety and consistent quality. Producers are increasingly using labels such as “organic,” “eco,” or “sustainable,” which strengthen consumer trust and allow them to obtain premium prices. Table 8 presents the main marketing trends in aquaculture and their impact on the market.

Table 8

**Marketing Trends in Aquaculture**

| <b>Trend</b>              | <b>Characteristic</b>                | <b>Market impact</b>                    |
|---------------------------|--------------------------------------|-----------------------------------------|
| Eco- and organic labeling | Certification, emphasis on purity    | Increased consumer trust, higher price  |
| Digital marketing         | Online promotion, social networks    | Expansion of market audience            |
| Direct sales              | Online stores, farmers' markets      | Reduced dependence on intermediaries    |
| Producer cooperation      | Formation of clusters, associations  | Joint entry into foreign markets        |
| Innovative packaging      | Vacuum, MAP, biodegradable packaging | Longer shelf life, export opportunities |

Digitalization of marketing plays a particularly important role. Ukrainian aquaculture enterprises are increasingly using social networks, online platforms, and electronic marketplaces to promote their products. This enables direct contact with consumers and the formation of long-term relationships through personalized offers. Internet marketing is becoming an important tool, especially targeting the younger generation of consumers, who pay considerable attention not only to price but also to the origin and ecological value of the product (Table 9).

Table 9

**Digital Marketing Tools in Aquaculture**

| <b>Tool</b>          | <b>Purpose</b>                       | <b>Example of use</b>             |
|----------------------|--------------------------------------|-----------------------------------|
| Social networks      | Brand promotion, customer engagement | Instagram, Facebook, TikTok       |
| Online stores        | Sales without intermediaries         | Producers' own websites           |
| E-commerce platforms | Market expansion                     | Rozetka, Prom.ua                  |
| Email marketing      | Personalized offers                  | Newsletters for regular customers |
| Big Data analytics   | Studying demand and trends           | Sales forecasting                 |

Innovative marketing solutions are closely linked to the development of packaging and logistics. Modern market requirements, particularly in the context of exports, demand not only high-quality fish but also the assurance of product preservation during transportation. The use of vacuum packaging, modified atmosphere packaging (MAP) technology, as well as biodegradable materials, not only extends the shelf life of products but also meets the standards of sustainable development (Table 10).

Table 10

**Innovative Solutions in Fish Product Packaging**

| <b>Type of packaging</b>            | <b>Features</b>                | <b>Advantages</b>                                           |
|-------------------------------------|--------------------------------|-------------------------------------------------------------|
| Vacuum packaging                    | Air removal                    | Extended shelf life                                         |
| MAP (Modified Atmosphere Packaging) | Use of special gas mixtures    | Freshness preservation without preservatives                |
| Biopackaging                        | Use of biodegradable materials | Environmental friendliness, attractiveness to eco-consumers |
| Smart packaging                     | Freshness sensors              | Real-time quality control                                   |
| Interactive labeling                | QR codes, AR technologies      | Access to product origin information                        |

An important direction of innovative marketing is producer cooperation. Clustering and the creation of associations make it possible

not only to use resources more effectively but also to increase competitiveness at the international level. Joint product promotion under a single brand strengthens the positions of Ukrainian producers in foreign markets and creates an economy of scale, reducing logistics and certification costs.

Thus, innovative approaches to marketing in Ukrainian aquaculture include digitalization, ecological product positioning, improved packaging, and the development of cooperative models. They create new opportunities for increasing the revenues of aquaculture enterprises, expanding sales markets, and integrating Ukraine into global supply chains. An effective marketing strategy that takes into account modern global trends can become a key factor of success for the industry in the context of growing competition.

International experience in marketing and fish market development shows that in Norway the “Norwegian salmon” [1] brand is one of the most successful examples of global marketing: it is based on ASC and MSC certification and wide presence in global retail networks. China is actively developing the domestic online aquaculture market through platforms such as Alibaba and JD.com, ensuring product traceability [7]. In EU countries (e.g., Spain, Denmark), the focus is on organic certification, biodegradable packaging, and transparency through QR codes [6]. The United States applies digital marketing with Big Data analytics to forecast demand and provide personalized offers to consumers [9].

In Ukraine, however, the level of ecological certification of fish products is low, the use of digital sales channels is limited, and producer cooperation is only beginning to take shape. This reduces competitiveness in foreign markets (Table 11).

Marketing innovations worldwide are based on the combination of digital tools, ecological certification, and producer cooperation. For Ukraine, a relevant task is the creation of the brand “Environmentally Friendly Ukrainian Fish,” the expansion of online sales channels, the development of innovative packaging, and the integration into international certification systems [10; 11]. Only under these conditions will Ukrainian products be able to compete in the global market.

Table 11

**Comparison of Marketing Innovations in Aquaculture  
(Ukraine vs. Leading Countries Worldwide)**

| <b>Country</b>             | <b>Marketing strategies</b>                               | <b>Packaging innovations</b>           | <b>Digital tools</b>                           | <b>Status in Ukraine compared to leaders</b>          |
|----------------------------|-----------------------------------------------------------|----------------------------------------|------------------------------------------------|-------------------------------------------------------|
| <b>Ukraine</b>             | Local markets, limited branding                           | Occasional use of vacuum packaging     | Limited use of social media and online sales   | Need for large-scale digitalization and certification |
| <b>Norway</b>              | Global brand “Norwegian salmon”, eco-certification        | MAP, biopackaging                      | Large-scale media campaigns, e-commerce        | Ukraine lacks a global brand                          |
| <b>China</b>               | Mass online sales through platforms, state export support | Innovative packaging for fast delivery | Platforms Alibaba, JD.com, mobile applications | Ukrainian e-commerce market still in its infancy      |
| <b>EU (Spain, Denmark)</b> | Eco- and organic certification, producer clusters         | Biopackaging, QR codes                 | Blockchain for traceability                    | No large-scale clusters in Ukraine                    |
| <b>USA</b>                 | Personalized digital marketing, Big Data analytics        | Smart packaging, freshness sensors     | CRM systems, predictive algorithms             | Ukrainian producers do not use Big Data               |
| <b>Canada</b>              | Producer cooperation, state promotion programs            | MAP, biopackaging                      | Social networks, online platforms              | Cooperation only at the initial stage in Ukraine      |

**5. Conclusions**

As a result of the study, innovative approaches to the sustainable development of aquaculture in Ukraine have been systematized, covering technical, ecological, and marketing dimensions. It has been shown that the modernization of the material and technical base of fisheries is an important prerequisite for improving its efficiency. The implementation of recirculating aquaculture systems (RAS), automated water quality monitoring, and energy-saving technologies allows for reducing production costs while decreasing environmental pressure on aquatic ecosystems.

Improvement of breeding and reproduction technologies also plays a significant role, opening opportunities for productivity growth and preservation of the gene pool of native fish species. At the same time, compared to leading countries, Ukraine lags significantly: in Norway and Iceland, automated management systems and intensive RAS are widely used; in China, aquaculture is supported by large-scale national programs; while in the USA and EU countries the focus is on digitalization, Big Data, and “green energy.”

Sustainable development of the sector is impossible without harmonizing economic activity with environmental protection tasks. Environmentally oriented technologies, such as biofiltration, integrated multi-trophic aquaculture (IMTA), and the restoration of natural biotopes, have already proven their effectiveness in Canada, Norway, and EU countries. In Ukraine, such innovations are implemented only in isolated cases, which requires systemic state support and incentives for enterprises.

The development of the fish products market in Ukraine largely depends on the effectiveness of marketing strategies. Global examples demonstrate that success is ensured by eco-certification, branding, and digital marketing: Norway has created a powerful global brand “Norwegian Salmon”; China has focused on online trade; the EU actively implements organic certification and biopackaging; and the USA uses Big Data to forecast demand. In Ukraine, these tools are applied only to a limited extent, which reduces competitiveness in foreign markets.

Thus, the integration of Ukrainian aquaculture into the global market is possible only under the condition of comprehensive modernization of technical processes, the implementation of environmentally safe technologies, and the scaling of modern marketing strategies. The synergy of scientific research, entrepreneurship, and state regulation should become a key factor in achieving a balance between economic benefits and the preservation of natural resources.

Prospects for further research and development are associated with a deeper study of the effectiveness of IMTA, the development of national standards of “green aquaculture” taking into account EU experience, the introduction of digital management technologies based on Big Data and IoT, as well as the adaptation of marketing strategies to global practices. This will strengthen the competitiveness of the Ukrainian fishery sector and contribute to its integration into the international fish market.

**References:**

1. Afewerki, S., Hermansen, Ø., & Aslesen, H. W. (2025). Reconfiguring innovation systems for sustainable sectoral transformation: The case of the Norwegian aquaculture industry. *Journal of the World Aquaculture Society*. DOI: <https://doi.org/10.1111/jwas.13124>
2. Brown, A. R., A. Ross Brown, & Charles R. Tyler (2025). Assessing the benefits and challenges of recirculating aquaculture systems (RAS). *Aquaculture International*, 33, 380–401. DOI: <https://doi.org/10.1080/23308249.2024.2433581>
3. Burhaz, M. I., & Soborova, O. M. (2025). Feed policy in Ukrainian aquaculture: Trends, challenges and impact on competitiveness. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies*, 27(102), 349–354. DOI: <https://doi.org/10.32718/nvlvet-a10249>
4. Hrytsynyak, I., & Shvets, T. (2024). Organic aquaculture in Ukraine and abroad: Thematic bibliography. *Ribogospod. nauka Ukr.*, 2024; 1(67): 177–190. DOI: <https://doi.org/10.61976/fsu2024.01.177>
5. Melnychenko, S. (2024). The dynamic of catching aquatic bioresources in southern Ukraine: Analysis of problems and perspectives in context of sustainable development. *Scientific Horizons*, 27(8), 158–167. DOI: <https://doi.org/10.48077/scihor8.2024.158>
6. Song, M., Li, T., & Andersen, T. (2025). Environmental impacts of aquaculture, marine shipping and blue R&D in Nordic countries *Environment, Development and Sustainability*, 27(2), 1931–1956. DOI: <https://doi.org/10.1007/s10668-025-06309-x>
7. Tiutiunnyk, H., Kolosov, A., & Hrytsak, N. (2024). Development of aquaculture in the Ukrainian Black Sea region: Organizational and economic measures and new approaches. March 1, 2024; Paris, France: VI International Scientific and Practical Conference «DÉBATS SCIENTIFIQUES ET ORIENTATIONS PROSPECTIVES DU DÉVELOPPEMENT SCIENTIFIQUE», 198–204. DOI: <https://doi.org/10.36074/logos-01.03.2024.001>
8. Dyudyayeva O. (2023) The state of the fish industry in the world and in Ukraine: development trends and global challenges. *Водні біоресурси та аквакультура*, 1(13), 24–40. DOI: <https://doi.org/10.32851/wba.2023.1.2>
9. State Agency for Land Reclamation and Fisheries of Ukraine. (2022, December 14). *On the prospects of attracting investment in the development of the fisheries sector*. Available at: [https://darg.gov.ua/\\_pro\\_perspektivi\\_zaluchennja\\_0\\_0\\_0\\_12243\\_1.html](https://darg.gov.ua/_pro_perspektivi_zaluchennja_0_0_0_12243_1.html)
10. Ukrinform. (2023, January 10). *Reforming the fisheries and land reclamation sector*. Available at: <https://www.ukrinform.ua/rubric-presshall/3647705-reformuvanna-galuzi-ribnogo-gospodarstva-ta-melioracii.html>
11. State Agency for Land Reclamation and Fisheries of Ukraine. (2023, March 17). *On the path of fundamental changes in the fisheries sector*. Ministry of Agrarian Policy and Food of Ukraine. Available at: <https://minagro.gov.ua/news/derzhribagentstvo-na-shlyahu-fundamentalnih-zmin-u-ribnij-galuzi>