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Aquaculture Clustering in Latvia: Opportunities, Threats and Development Perspectives

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ABSTRACT

Aquaculture in Latvia as a sector is growing slowly, it requires specific knowledge, professional skills and serious investments, but the aquaculture sector has a perspective, which is facilitated by the geographical location of Latvia, water resources and access to the EU market. In order to promote the competitiveness and sustainable development of the aquaculture sector, a clustering of aquaculture enterprises is necessary. The purpose of this study is to identify clusters for aquaculture enterprises in Latvia. 56 Latvian aquaculture enterprises were interviewed, which explains 82% of the total number of aquaculture enterprises in Latvia. To achieve this goal, a factor and cluster analysis was created using the IBM SPSS program. The author raised 10 factors based on economic, social and financial factors. The author concluded that there are differences in the aquaculture sector in different regions of Latvia, depending on the specific characteristics of the territory, the problems of fish farming methods and financing. However, in order to better address these problems, a solution is proposed to promote the development of aquaculture entrepreneurship, which would create new jobs and reduce unemployment in the country, as well as promote the growth of fish as food resources. This could help Latvian aquaculture policymakers to work more successfully and improve the common policy in the aquaculture sector.

Keywords: Aquaculture; Fisheries policy, Latvia, clusters.

INTRODUCTION

In the context of global food security and sustainable development, the aquaculture sector is emerging as an increasingly vital source of fish and seafood, serving to supplement the diminishing yields from overexploited wild fisheries [1;5;2]. In the EU, aquaculture development is a strategic objective linked to low carbon emissions, innovation and regional development [4;9]. In Latvia, despite the sector's potential, its growth has progressed at a relatively modest pace. The primary constraints hindering development are the limited availability of specialised expertise, insufficient investment, a small number of operating enterprises, and a low level of sectoral cooperation [3;7;12].

Aquaculture development in Latvia has thus far primarily relied on the independent initiatives of individual companies, rather than on coordinated sector-wide policies or collaborative frameworks. Although various support instruments are available at both the national and EU levels, their effectiveness is often constrained by the sector's fragmentation and low level of organisation. This situation impedes the application of scientific knowledge as well as the development of shared solutions adapted to local environmental and economic conditions. There is, therefore, a risk that Latvia may fail to fully realise the potential of aquaculture development unless strategic planning and stronger integration among enterprises, research institutions and policymakers are actively promoted.

Latvia has a number of prerequisites for aquaculture development – its geographical location, water resources and access to the European single market [11;5]. To more effectively leverage these factors, it is essential to promote business cooperation and establish an organisational framework capable of integrating innovation, scientific knowledge and collective marketing efforts. One recognised approach to fostering such cooperation is enterprise clustering [13;8]. In Latvia, considering the sector's structural and geographical particularities, there is significant

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potential to develop several thematically or regionally focused aquaculture clusters. Such clusters could specialise, for example, in recirculation systems, pond management, biotechnology applications or processing of aquaculture products. Each cluster could serve as a hub for knowledge and innovation, effectively aligning academic resources with the practical needs of the industry. Such structures would also support the development of exportable brands and contribute to positioning Latvian aquaculture as a high-quality, sustainable niche producer within the European market.

Regional development and socio-economic cohesion are also important aspects of creating enterprise clusters. The sustainable exploitation of aquatic biological resources can generate employment opportunities in rural areas, particularly where alternative economic activities are limited. Clusters can also foster synergies with other sectors – such as agriculture, biotechnology, tourism, and education – forming a foundation for a diversified and resilient regional economy. In this context, public engagement, community involvement and place-based development strategies are of particular significance.

Clustering encompasses not only geographical proximity and the concentration of enterprises, but also functional connectivity grounded in shared knowledge transfer, technological advancement, joint market research, and export potential. Such cooperation is particularly vital for smaller countries with limited domestic markets, as synergies among sectoral stakeholders can generate greater added value and enable a more effective response to global challenges. Cluster structures are linked to increased levels of innovation, higher business survival rates and enhanced regional competitiveness [4]. Clustering within the agriculture and aquaculture sectors enables companies to share resources, reduce operational costs and adopt new technologies more efficiently [10;6]. Research shows that clustered enterprises are also more resilient to market and climate risks [14;7].

While clustering does not automatically ensure success, it offers a structured platform that balances individual business interests with the broader developmental needs of the sector. However, successful cluster development necessitates a coordinated approach – comprising a strategic vision from the national government, supportive mechanisms from local and regional authorities, and clearly defined objectives from the business community. This process is significantly enhanced by academic institutions, which provide research, training and a scientific foundation for innovation.

The aim of this study is to identify potential clusters of aquaculture enterprises in Latvia, evaluate their development prospects, analyse associated risks, and formulate strategic recommendations to enhance the competitiveness of the sector. In this context, both the existing cooperation structure and possible development trajectories will be assessed, taking international experience and local circumstances into account.

The purpose of this study is to identify clusters for aquaculture enterprises in Latvia.

MATERIALS AND METHODS

To establish an objective overview of the aquaculture sector in Latvia and to evaluate its strengths and weaknesses, a quantitative research approach was employed, enabling the identification of general trends among aquaculture operators rather than focusing on individual or isolated cases. The chosen data collection method was a survey, for which a survey instrument – a questionnaire – was developed. The survey of aquaculture enterprises was carried out electronically by sending a link to the questionnaire by personal e-mail between 11 February and 1 March 2025. For data quality control purposes, access to the electronic questionnaire was restricted, and each questionnaire could only be completed once per electronic device.

To achieve the objective of the research, factor and cluster analysis was performed with the use of IBM SPSS software. Factor and cluster analysis was carried out for the 56 Latvian aquaculture enterprises, which explains 82% of the total number of aquaculture enterprises in Latvia on the basis of 10 factors identified by the author, based on economic, social and financial factors. The fact that 82% of Latvian aquaculture enterprises participated in the survey means that the results are representative and can be applied to the Latvian aquaculture sector as a whole. Data were sourced from interviews with aquaculture enterprises. Analysis, synthesis, the logical construction method, as well as the induction and deduction methods, were employed to execute the research tasks. Scientific literature review was used as well.

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RESULTS

An in-depth analysis is required to identify the key influencing factors affecting the situation of Latvian aquaculture enterprises. Political, technological, social, and economic conditions vary from one enterprise to another; thus, it is important to use clustering techniques to identify the problem factors. In this study, factor analysis is used to identify the complex factors that characterise the situation of Latvian aquaculture enterprises. These factors are necessary because they cannot be observed directly and are not correlated. Factor analysis allows the identification of linearly dependent complex factors that are not correlated.

The selection of this method was based on its appropriateness for achieving the objectives of the study. Ten variables were developed for fish farms in Latvia to examine correlations among baseline characteristics and to reduce them into a smaller set of factors for assessing the status of aquaculture enterprises.

Bartlett's test shows a significant correlation between traits if its significance is less than 0.05. The Kaiser-Meyer-Olkin test, on the other hand, requires a value greater than 0.5 to assess the sampling of variables (Hair, Black et al., 2009). From the test results shown in Table 1, it can be concluded that the Kaiser-Meyer-Olkin test has a significance of 0.500, while the Bartlett test has a significance of less than 0.05. This indicates that the group of conditions created by the factor analysis is significant, and the use of factor analysis is justified (See Table 1).

Table 1: Results of the Kaiser-Meyer-Olkin and Bartlett's tests

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,500
Bartlett's Test of Sphericity	Approx. Chi-Square	84,394
	df	45
	Sig.	0,000

Source: SPSS Output

Using Kaiser's test, four groups of factors were identified, which together explain 84.3% of the variance or potential differences in Latvian aquaculture enterprises. Two of these factors, with an eigenvalue above 1, account for 58.8% of the total number of variables. These results are very good considering the fact that four of the 10 original variables were extracted and 15.7% of the total variance of the data was lost (see Table 2). This means that three complex factors can be distinguished. This indicates that three complex factors can be distinguished.

Table 2: Number of factors and explained variance in the factor analysis of the situation of Latvian aquaculture enterprises

Factor groups	Factor eigenvalues			Inverse sums of squared loadings		
	Total	% of variance explained	Accumulated %	Total	% of variance explained	Accumulated %
1	13.2	57.5	57.5	13.2	57.5	57.5
2	4.5	19.6	77.2	4.5	19.6	77.2
3	2.0	8.8	84.3	2.0	8.8	86.0

Source: SPSS Output

The calculated Component Matrix (see Table 3) summarises the elements of the identified factor groups, allowing for the interpretation and naming of factors or conditions based on their content.

Table 3: Factor analysis of complex factors in Latvian aquaculture enterprises and their components (Component Matrix)

Factor elements	FACTORS		
	1	2	3
Size of the enterprise			0.552

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Factor elements	FACTORS		
	1	**2**	**3**
Duration of the enterprise	0.807		
Turnover of the enterprise			0.737
Fish farming area	0.733		
Species of fish farmed		0.262	
Type of fish farming		0.290	
Fish farming intensity		0.630	
Number of people working in the aquaculture enterprise	0.758		
Type of fish feed used at the enterprise		0.776	
Sources of income for the enterprise	0.198		

Source: SPSS Output

The author's factor analysis shows that *the first group of factors* (explaining 58% of the conditions) includes *4 elements:*

- duration of the aquaculture enterprise;
- fish farming area;
- number of people working in the aquaculture enterprise;
- sources of income for the enterprise;

The second group of factors (explaining 19% of conditions) includes *4 elements*:

- species of fish farmed by the enterprise;
- type of fish farming;
- intensity of fish farming;
- type of fish feed used at the enterprise;

The third group of factors (explaining 9% of the conditions) consists of *2 elements*: the size of the enterprise and turnover.

In order to determine more precisely which variables make up each of the two elements of the complex factor, a rotated factor matrix is calculated. Factor rotation is also essential for simplifying interpretation and enhancing the evaluation of factor structures in relation to the obtained results. This process uses a varimax rotation method. The varimax approach provides an orthogonal rotation between several factors in order to maximise the dispersion of the squared loadings. This is the most commonly used method of the various rotations available. It can be concluded that the elements of the complex factors have not changed significantly after their application based on the factor loadings (see Table. 4).

Table 4: Structure of rotated component factor loadings for Latvian aquaculture enterprises *(Rotated Component Matrix)*

Factor elements	Components		
	1	**2**	**3**
Size of the enterprise			**0.775**
Duration of the enterprise	**0.868**		

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Factor elements	**Components**		
	1	**2**	**3**
Turnover of the enterprise			**0.771**
Fish farming area	**0.749**		
Species of fish farmed		-0.342	
Type of fish farming		-0.428	
Fish farming intensity		**0.830**	
Number of people working in the aquaculture enterprise	**0.751**		
Type of fish feed used at the enterprise		**0.679**	
Sources of income for the enterprise	0.235		

Source: SPSS Output

Based on the two complex factors identified, it is important for future research to pinpoint those aquaculture enterprises in Latvia where targeted contributions are crucial for addressing the challenges facing aquaculture development. When analysing Latvian aquaculture enterprises, it is necessary to classify all the entities under study based on complex factors to facilitate more effective comparison. This can be done using a clustering method.

The analysis was repeated with the use of K-means clustering. Based on the factor values resulting from the factor analysis, Latvian aquaculture enterprises can be divided into five groups or clusters (see Table 5).

Table 5: Clusters in Latvian aquaculture enterprises

Cluster name	**Number of enterprises**	**Main characteristics**
Economically developed cluster	1	Large enterprise, significant turnover, large number of employees.
Economically negative cluster	18	Small number of employees, low turnover, small area of fish farming, fish farming in ponds, uniform range of farmed species (mostly carp), feeding fish with grain.
Economically positive cluster	20	Medium economic activity, high work experience of the enterprise, large areas for fish farming, and a relatively high number of employees.
Economically mature cluster	2	The largest work experience in aquaculture, large fish farming areas, income mainly from aquaculture, fish farming in ponds and recirculation systems, and common farmed fish species.
Economically active cluster	13	The highest activity of fish farming, microenterprises, small number of employees, fish farming in large areas, diverse species of fish, different types of fish feed and breeding methods.

Source: developed by the author

By using the principle of mutual comparison of the groups, it was found that each cluster can be assessed in accordance with the characteristics of the situation in the cluster. The first group of factors – the enterprise factor group – is the most significant, as it directly characterises the aquaculture enterprises.

DISCUSSION

Clusters are grouped and defined as follows:

1. Economically developed cluster - a large enterprise, significant turnover, a large number of employees
2. Economically negative cluster - small number of employees, low turnover, small area of fish farming, fish farming in ponds, uniform range of farmed species (mostly carp), feeding fish with grain. Economically positive cluster - medium economic activity, high work experience of the enterprise, large areas for fish farming, relatively high number of employees.
3. Economically mature cluster - the largest work experience in aquaculture, large fish farming areas, income mainly from aquaculture, fish farming in ponds and recirculation systems, common farmed fish species.
4. Economically active cluster - the highest activity of fish farming, microenterprises, small number of employees, fish farming in large areas, diverse species of fish, different types of fish feed and breeding methods.

CONCLUSIONS

1. Limited species diversity and traditional feeding practices may hinder competitiveness and profitability in the long term.
2. Investment in technology, diversification of farmed species, and modernization of breeding methods are crucial development perspectives.
3. Improving financial performance and supporting knowledge transfer across clusters will enhance overall sector resilience.
4. A strong focus on innovation, environmental sustainability, and export development is essential for long-term success.
5. Latvia's aquaculture has the potential to become a dynamic, competitive, and sustainable industry with targeted support and strategic development.

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