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Impact of IoT Monitoring in Fish Farming: A Comprehensive Systematic and Bibliometric Review

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Abstract. Internet of Things (IoT)-based monitoring is transforming fish farming towards a more sustainable practice, thanks to the automation and simplification of data management. This process captures a range of environmental parameters, such as temperature and water quality, thus improving the management of aquacultural spaces. This evolution promises to increase production, raise product quality, and reduce operational costs. The purpose of this study is to investigate the repercussions of IoT monitoring in fish farming, assessing both positive and negative influences, through a Systematic Literature Review (SLR) covering the period from 2017 to 2023 and examining databases such as Scopus, IEEE Xplore, ScienceDirect, Google Scholar, Web of Science, and ACM Digital Library. Applying rigorous exclusion criteria — discarding papers older than seven years, not in English, not published in peer-reviewed conferences or journals, not available in full text, or not offering specific solutions for aquaculture — 60 significant papers were selected from a total of 2569. The results indicate that IEEE Xplore is the dominant source within the retrieved literature and that the journal Sensors appears frequently among the selected studies, with a notable contribution from Asian countries. This work reveals crucial discoveries about the application of IoT in aquaculture and its varied contexts of use.

Keywords. Aquaculture, internet of things, IoT, systematic review, IoT monitoring, fish farm.

1 Introduction

Fish farming, a globally significant industry, produces over 100 million tons annually. In this context, the Internet of Things (IoT), an emerging and rapidly developing technology, holds revolutionary potential for this sector. IoT-based devices have the capability to collect data on various critical parameters, including water quality, fish health, and their feeding patterns.

The efficient use of these data can optimize operations in fish farming and contribute significantly to the well-being of the fish, thus

marking a notable advancement in the management and sustainability of this industry.

Abid and colleagues [1] model data-driven approaches for sustainable aquaculture within the Global IoT Summit context. Building on IoT-based monitoring approaches, Abinaya and coauthors [2] propose an innovative methodology for monitoring and controlling water quality in aquaculture using IoT technologies.

Similarly, Abraham and collaborators [3] investigate remote environmental monitoring using IoT, demonstrating its applicability for tracking water quality, temperature, and other environmental variables in fish farms. Complementarily, Acar and the research team [4] design a cloud-based IoT solution for aquaculture that enables the collection and storage of sensor data to support operational optimization.

From an application-oriented perspective, Agusa and other authors [5] develop a seawater temperature announcement system aimed at improving the efficiency of the fishing industry through IoT-based data acquisition. In the context of integrated farm intelligence, Al-Mutairi and Al-Aubidy [6] propose an IoT-based smart monitoring and management system for fish farming environments. At a broader technological scope, Anastasiou and colleagues [7] review extended reality applications across agriculture, livestock, and aquaculture domains. Likewise, Angani and coauthors [8] implement an IoT-based eel farm system supported by MQTT flow control and artificial intelligence techniques.

Beyond individual implementations, Bernal-Higuita and other authors [9] conduct a systematic review of ICT solutions to enhance sustainable productivity in freshwater aquaculture, identifying variability in sensor accuracy and reliability. At the communication-architecture level, Bhawiyuga and coauthors [10] propose a LoRa–MQTT gateway device to support reliable sensor-to-cloud data transmission in smart aquaculture IoT applications. Similarly, Billah and colleagues [11] develop a real-time water quality monitoring system to maintain fish farm conditions. In the same vein, Chen and collaborators [12] design an IoT-based water quality monitoring system, while Chiu and coauthors [13] develop a smart aquaculture farm management system integrating IoT and AI-based surrogate models.

Focusing on control automation, Chuyen and the research team [14] design and manufacture a water quality control system based on IoT technology for aquaculture in Vietnam. From a cloud monitoring perspective, Cordova-Rozas and colleagues [15] propose an IoT-based aquaculture monitoring architecture. For autonomous sensing scenarios, Davis and collaborators [16] develop and field-test path planning for robotic water quality monitoring in aquaculture environments. In parallel, Den Ouden and coauthors [17] examine hybrid aerial–underwater robotic systems for aquaculture monitoring. Finally, Desai and the research team [18] present an IoT-based pisciculture monitoring system, reinforcing the growing adoption of intelligent monitoring technologies in fish farming.

Recent developments in smart and precision agriculture also confirm that IoT-based monitoring has become increasingly relevant beyond conventional crop management, particularly when combined with advanced data analytics and artificial intelligence. Andrade-Mogollon and colleagues [72] showed that the convergence of Generative AI and IoT supports real-time monitoring of critical variables such as soil moisture, temperature, crop health, and early pest and disease detection, while also enabling low-cost architectures and advanced analytical solutions for decision-making in agricultural systems.

Although this recent study is outside the 2017-2023 search window of the present systematic review and is not part of the PRISMA corpus, it reinforces the current relevance of IoT-based monitoring as a cross-domain technological approach for sustainable food-production systems. In addition to monitoring and automation benefits, IoT-based systems also require a stronger security perspective because connected devices collect, transmit, and process sensitive operational data. Padilla-Gomez and collaborators [73] emphasize that cybersecurity in IoT environments is essential to prevent, detect, and manage cyber-attacks, particularly because IoT devices generate large volumes of data that require authentication, confidentiality, integrity, and availability safeguards. Although their review focuses on cyber-attacks targeting IoT devices and is outside the 2017-2023 corpus of the present review, its

findings are relevant to fish-farming monitoring systems because aquaculture platforms increasingly depend on connected sensors, cloud services, and networked data flows.

The distinctive value of this research lies in its focus on answering essential questions and examining the tangible impact of IoT Monitoring in Fish Farming, an area that has thus far received limited attention in previous research.

This study has not only identified deficiencies and trends in the field but has also outlined specific gaps, thus providing a solid foundation for future inquiries in this realm. Its main contribution is to offer an essential guide for both researchers interested in exploring IoT Monitoring in Fish Farming and for professionals implementing this emerging technology, facilitating a more effective and appropriate approach in their respective endeavors. Despite the advances made, there is still a wide margin for improvement. This study stands out from the existing literature in the area for its specific coverage of research gaps, addressing aspects such as the evaluation criteria of fish farming with IoT, quartile levels of publications, and analysis of the most productive authors, countries, and publications in this field.

Therefore, the objective of this systematic review is to understand the current state of the literature on the use of IoT in fish farming. The review will identify the key benefits of using IoT in fish farming, the challenges that need to be addressed, and future directions for research in this area. This study offers a comprehensive and well-structured analysis of the phases executed in the systematic literature review. Section 2, Review Methodology, details the procedure followed to conduct the review. The Results obtained and their corresponding analysis are found in Section 3. Finally, Section 4, Conclusions and Future Research, addresses the conclusions derived from the study and outlines possible directions for future research in this field.

2 Review Methodology

This study adopts a systematic literature review approach has been chosen, following the guidelines proposed by B. Kitchenham [71], as illustrated in Fig. 1. This method is applied to

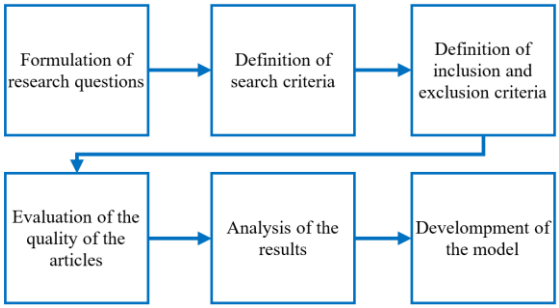


Fig. 1. Stages of the SLR

perform a detailed and in-depth analysis of the impact of IoT monitoring in fish farming, aimed at answering the previously established research questions. It is essential to keep a meticulous record of the entire review process, including the creation of a detailed database containing the search equations used, the exclusion criteria, and the methods of quality assessment employed.

The purpose of this rigorous record-keeping is to ensure that the study's results are consistent, reliable, and conclusive.

2.1 Research Problems and Objectives

The importance of research on IoT monitoring in fish farming underscores the need for a meticulous and effective search strategy. This strategy should be designed to efficiently collect relevant data from each study, thereby enabling thorough and pertinent analysis. Research Questions (RQs) are crucial in this process, directing the search towards specific and relevant topics. In the context of this study, five research questions have been formulated, each with clearly defined objectives, which are detailed in Table 1. This structuring ensures that the review is focused, comprehensive, and aligned with the overall objectives of the research.

2.2 Information Sources and Search Strategies

For the compilation of relevant research studies, a diverse set of academic and scientific databases was used. The platforms selected for this search included Scopus, IEEE Xplore, ScienceDirect, Google Scholar, Web of Science, and ACM Digital Library. This choice ensures a broad scope and

Table 1. Research questions and objectives

Research Question	Objective
RQ1: In which quartiles are the research studies that address the influence of IoT-based monitoring within the realm of fish farming classified?	Identify the quartiles of publications related to IoT monitoring and its impact on fish farming
RQ2: What keywords appear most frequently in academic papers that focus on the use of IoT technologies for the supervision of fish farming activities?	List the most frequently used keywords in publications about IoT monitoring and fish farming
RQ3: Which researchers have contributed most extensively and what are the most prominent nations in the field of study of IoT impact on fish farming management?	Enumerate the most productive authors and countries on IoT monitoring and its influence on fish farming
RQ4: What are the criteria used to evaluate fish farming through IoT monitoring?	Display the criteria used for evaluating fish farming through IoT monitoring
RQ5: Which publications, focused on the research of fish farming through IoT, present abstracts with a high degree of objectivity and minimal biased tendency?	Extract papers whose abstracts are characterized by high objectivity and low polarity in research on IoT monitoring in fish farming

Table 2. Search descriptors and their synonyms

Descriptor	Synonyms
monitoring of iot	/ iot / internet of things
pisciculture	aquaculture/fish farm

access to a vast range of relevant literature in the field.

The adopted search method was based on the use of specific keywords, which have been detailed and organized in Table 2.

This keyword search approach allows for a systematic and focused exploration of publications, ensuring that the studies collected are relevant to the topics of interest in this research.

The search methods used in this research are based on a carefully designed set of terms, functioning as key tools to facilitate the efficient extraction and summarization of relevant information. These terms are grouped into what is known as a search equation.

Each search equation has been specifically adapted to suit the corresponding information source, reflecting differences in the formats and indexing systems of each database.

This adaptation ensures that the search is both comprehensive and precise, thus maximizing the relevance and quality of the studies collected. The specific details of these search equations, including variations according to the database used, are presented in Table 3.

2.3 Identified Studies

Upon completing the search process across various information sources, a set of research studies was compiled, the totals of which are reflected in Fig. 2.

This collection represents the result of the meticulous application of the search equations in each database. The figure shows the number of relevant papers obtained from each source, providing a clear and quantitative view of the scope of the search performed and the distribution of relevant studies among different academic and scientific platforms.

These totals are fundamental to understanding the magnitude of the available literature on the topic and serve as a basis for the subsequent phases of analysis and synthesis in the research.

To combine the datasets obtained from various databases (Scopus, IEEE Xplore, ScienceDirect, Google Scholar, Web of Science, ACM Digital Library), the following steps were taken:

(1) Exporting results in standard-compatible formats, such as .csv or .ris;

(2) Normalizing key fields (title, author, year, keywords) using Mendeley Desktop to unify the structure of the records;

(3) Removing duplicates by matching titles and authors; and

(4) Classifying the filtered records according to the exclusion criteria established in the study. This

Table 3. Information sources and search equations

Source	Search Equation
Scopus	TITLE-ABS-KEY ((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm)) OR KEY ((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm) OR ABS ((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm))
IEEE Xplore	((All Metadata:iot OR All Metadata:internet of things OR All Metadata:monitoring of IoT) AND (All Metadata:pisciculture OR All Metadata:aquaculture OR All Metadata:fish farm)) OR ((Document Title:iot OR Document Title :internet of things OR Document Title :monitoring of IoT) AND (Document Title :pisciculture OR Document Title :aquaculture OR Document Title :fish farm)) OR ((Abstract:iot OR Abstract :internet of things OR Abstract:monitoring of IoT) AND (Abstract :pisciculture OR Abstract:aquaculture OR Document Title :fish farm))
ScienceDirect	title, abstract, keywords: (iot OR internet of things OR monitoring of iot) AND (aquaculture OR pisciculture OR fish farm)
Google Scholar	intitle:(monitoring of IoT OR IoT OR internet of things) intitle:(pisciculture OR aquaculture OR fish farm)
Web of Science	((Tl-((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm))) OR (AB-((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm))) OR (AK-((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm))) OR (AB-((monitoring of iot OR iot OR internet of things) AND (pisciculture OR aquaculture OR fish farm))))
ACM Digital Library	[[All: monitoring of iot] OR [All: iot] OR [All: internet of things]] AND [[All: pisciculture] OR [All: aquaculture] OR [All: fish farm]]

process ensured the efficient integration of the data for subsequent analysis.

2.4 Selection Criteria

The Exclusion Criteria (EC) play a vital role in the process of evaluating and selecting literature to ensure the quality and relevance of the studies included in this research. Selected papers must meet a series of objective criteria, designed to filter out works that do not closely align with the objectives and scope of the study. In total, eight exclusion criteria have been applied, detailed as follows:

- EC1: Papers are older than 7 years
- EC2: Papers are not in English
- EC3: Papers were not published in peer-reviewed conferences or journals
- EC4: Titles and keywords of the papers are not very relevant
- EC5: Full text of the paper is not available
- EC6: Abstract of the papers is not very relevant
- EC7: Papers do not propose a solution for aquaculture
- EC8: Papers contain very little information.

2.5 Selection of Studies

After a thorough review of relevant sources and the application of appropriate search equations, 2569 papers were identified as potentially relevant to the study, selected based on their pertinence and the use of specific keywords related to the research.

The selection and filtering process for these papers was carried out following a series of meticulous and structured steps, detailed in Fig. 3, titled PRISMA Diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). PRISMA is a widely recognized methodology for structuring systematic reviews and meta-analyses, designed to ensure transparency and reproducibility in the processes of selecting, screening, and analyzing studies. In this work, it was applied to guarantee a rigorous and

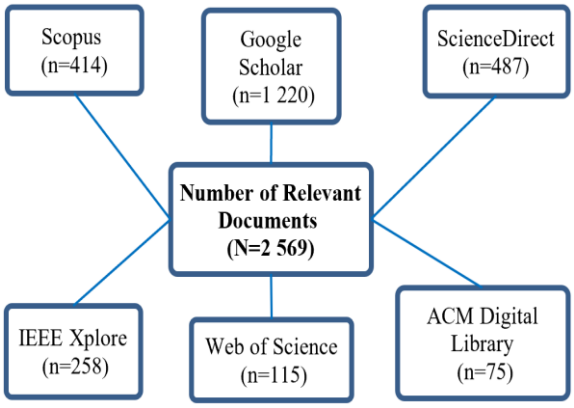


Fig. 2. Number of relevant documents identified

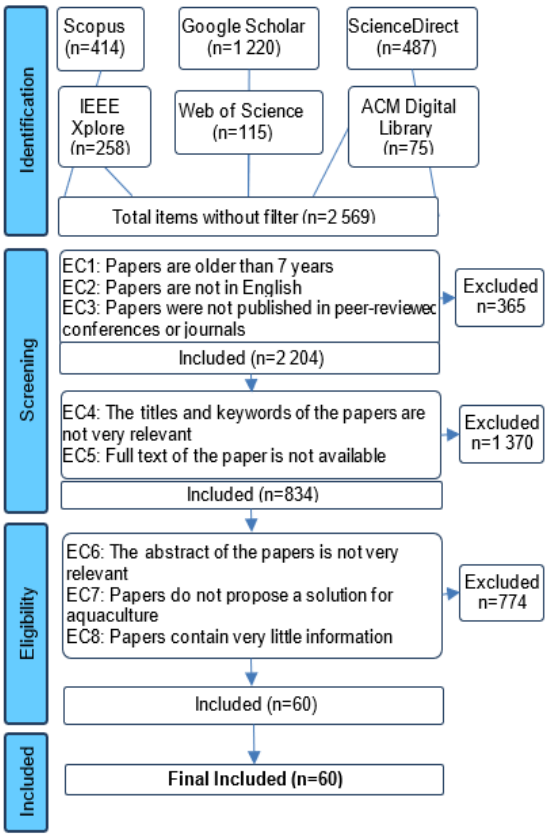


Fig. 3. PRISMA Flow Diagram

standardized approach in the selection and evaluation of articles, clearly and transparently documenting how studies were identified, selected, and included.

This strengthens the credibility and robustness of the results obtained. More information about PRISMA is available at the link in footnote[1].

The results reflected in the figure were obtained article by article, combining automated and manual procedures.

The first screening phase was automated, while the eligibility phase was conducted manually, ensuring the individual evaluation of each article against the established criteria.

2.6 Quality Assessment

In this crucial phase of the process, a detailed analysis of the previously selected papers was conducted, applying seven Quality Assessment (QA) criteria.

The purpose of this final stage of selection and filtration was to ensure the comprehensibility and veracity of the research presented in each paper.

For this, papers were evaluated according to these quality criteria, assigning corresponding values that reflect their compliance.

In this final phase of selection and filtration, the results of the application of these criteria along with their corresponding values were obtained, with the purpose of ensuring the comprehensibility and the veracity of each research described in the papers, as shown in Table 4.

The seven QAs were validated through a rigorous process that included a review based on recognized methodologies from the literature, input from experts in IoT and aquaculture, and a pilot test applied to a subset of articles.

This process ensured that the questions were relevant, clear, and consistent with the study's objectives, providing a solid foundation for the final evaluation of the selected articles.

For each paper that was analyzed in its entirety, the 7 criteria were employed to analyze its quality using a scale. A rating of 1 to 3 was used (1 = Poor, 2 = Fair, and 3 = Excellent) with the minimum score for exclusion being 2.10.

As a result of the evaluation of the 60 papers, it was confirmed that all primary studies obtained a high-quality rating, meeting the Quality

[1] https://www.prisma-statement.org/

Table 5. Results of the quality assessment

Ref.	Type	QA1	QA2	QA3	QA4	QA5	QA6	QA7	Score	Ref.	Type	QA1	QA2	QA3	QA4	QA5	QA6	QA7	Score
[1]	Conference	3	3	3	3	3	3	3	3.00	[31]	Conference	3	3	3	3	3	3	3	3.00
[2]	Conference	3	3	3	3	3	3	3	3.00	[32]	Conference	3	3	3	3	3	3	3	3.00
[3]	Conference	3	3	3	2	3	3	3	2.86	[33]	Conference	3	3	3	3	3	3	3	3.00
[4]	Conference	3	3	3	3	3	3	3	3.00	[34]	Conference	3	3	3	3	3	3	3	3.00
[5]	Journals	3	3	3	2	3	3	3	2.86	[35]	Conference	3	3	3	3	3	3	3	3.00
[6]	Journals	3	3	3	3	3	3	3	3.00	[36]	Conference	3	3	3	3	3	3	3	3.00
[7]	Journals	2	3	2	3	3	1	3	2.43	[37]	Conference	3	3	3	3	3	3	3	3.00
[8]	Conference	3	3	3	3	3	3	3	3.00	[38]	Conference	3	3	3	3	3	3	3	3.00
[9]	Journals	2	3	3	3	3	1	3	2.57	[39]	Conference	3	3	3	3	3	3	3	3.00
[10]	Conference	3	3	3	3	3	3	3	3.00	[40]	Conference	3	3	3	3	3	3	3	3.00
[11]	Conference	3	3	3	3	3	3	3	3.00	[41]	Conference	3	3	3	3	3	3	3	3.00
[12]	Journals	3	3	3	3	3	3	3	3.00	[42]	Journals	3	3	3	3	3	3	3	3.00
[13]	Journals	3	3	3	3	3	3	3	3.00	[43]	Journals	3	3	3	3	3	3	3	3.00
[14]	Journals	3	3	3	3	3	3	3	3.00	[44]	Conference	3	3	3	3	3	3	3	3.00
[15]	Conference	3	3	3	3	3	3	3	3.00	[45]	Conference	3	3	3	3	3	3	3	3.00
[16]	Journals	3	3	3	3	3	3	3	3.00	[46]	Journals	3	3	3	2	3	3	3	2.86
[17]	Journals	3	3	3	3	3	3	3	3.00	[47]	Conference	3	3	3	3	3	3	3	3.00
[18]	Conference	3	3	3	3	3	3	3	3.00	[48]	Conference	2	3	3	2	3	1	3	2.43
[19]	Journals	1	3	3	2	3	1	3	2.29	[49]	Conference	3	3	3	3	3	3	3	3.00
[20]	Conference	3	3	3	3	3	3	3	3.00	[50]	Journals	3	3	3	3	3	3	3	3.00
[21]	Conference	3	3	3	3	3	3	3	3.00	[51]	Conference	3	3	3	3	3	3	3	3.00
[22]	Conference	3	3	3	3	3	3	3	3.00	[52]	Journals	3	3	3	3	3	3	3	3.00
[23]	Conference	3	3	3	3	3	3	3	3.00	[53]	Journals	2	3	2	2	2	2	2	2.14
[24]	Journals	3	3	3	3	3	3	3	3.00	[54]	Journals	3	3	3	3	3	3	3	3.00
[25]	Journals	3	3	3	3	3	3	3	3.00	[55]	Journals	3	3	3	3	3	3	3	3.00
[26]	Conference	3	3	3	3	3	3	3	3.00	[56]	Journals	3	3	3	3	3	3	3	3.00
[27]	Journals	3	3	3	3	3	3	3	3.00	[57]	Conference	3	3	3	3	3	3	3	3.00
[28]	Journals	3	3	3	3	3	3	3	3.00	[58]	Journals	2	3	3	2	3	1	3	2.43
[29]	Journals	3	3	3	3	3	3	3	3.00	[59]	Journals	3	3	3	3	3	3	3	3.00
[30]	Conference	3	3	3	3	3	3	3	3.00	[60]	Journals	3	3	3	3	3	3	3	3.00

Assessment (QA) criteria with a score equal to or greater than 2.14.

This evaluation conclusively defined the number of publications to be included in the study, as shown in Table 5.

2.7 Data Extraction Strategies

This section details the use of Mendeley Desktop version 1.19.5, a comprehensive software tool for bibliographic management. Mendeley has been

instrumental in organizing the collected papers, allowing easy classification and access to relevant documents.

2.8 Synthesis of Findings

Finally, after the data were extracted to address the research questions, they were analyzed and presented and presentation in the form of tables and graphs, followed by a comparison with similar research. These analyses revealed various patterns and trends in the research over the past seven years. In this phase, the collected data were consolidated, and responses to the posed research questions were generated. To carry out this data synthesis process, various statistical techniques were employed, where the information obtained for each research question was organized into tables and presented in the form of quantitative data. These quantitative data were subsequently used to perform statistical comparisons between the different findings obtained.

3 Results and Discussion

This section details the most relevant and significant findings discovered during the research. It discusses how these findings align or diverge from previous studies in the field, providing a deeper understanding of the subject. The discussion also addresses the practical implications of the results, suggesting how they might influence future practice, policy, or further research in the field. This section is essential for understanding the scope and significance of the study, as well as for placing its findings within the broader academic and practical context.

3.1 General Description of the Studies

After the selection process, 60 studies were identified for data extraction and analysis. Fig. 4 shows the number of publications generated on IoT monitoring and its impact on fish farming over the last 7 years, highlighting 2019 as the year with the highest number of publications.

The results show that 2019 was the most productive year with 16 publications related to the terms of this systematic review, followed by 2023, which, given that we are in the first half, already has 10 publications, equaling 2020.

Considering that there is still more than half a year left in 2023, it is likely that this year will record a higher number of publications compared to other years.

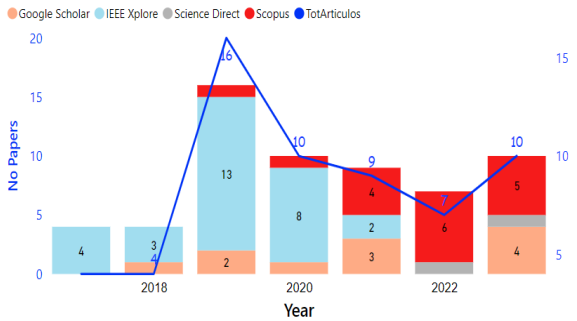
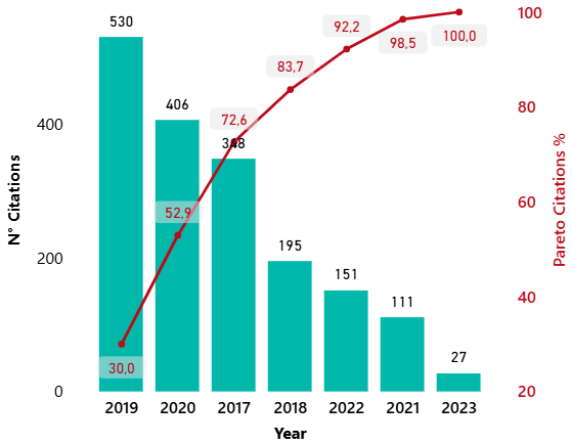


Fig. 4. Distribution of studies by year and source



Year	N° Citations	Total Citations	Pareto Citations	Citations/ Paper
2019	530	530	30.0	33
2020	406	936	52.9	41
2017	348	1284	72.6	87
2018	195	1479	83.7	49
2022	151	1630	92.2	22
2021	111	1741	98.5	12
2023	27	1768	100.0	3
Total	**1768**			**29**

Fig. 5. Pareto chart of citations by year

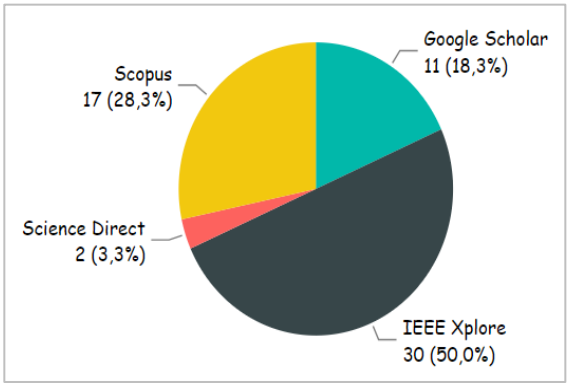


Fig. 6. Distribution of studies published by source

In the systematic review-type publications referenced by [9-18], a question similar to the present one is not specifically addressed. However, these publications do conduct exhaustive reviews of various technical concepts related to sensors and IoT communication interfaces in fish farming. For example, in the study by [9], papers published in different periods related to IoT sensors for water quality are analyzed.

As can be seen, among the papers that met the exclusion criteria, the most productive year was 2019. However, due to confinement and the pandemic, publications have decreased. Nevertheless, the year 2023 seems to indicate that it will have the highest number of publications by the end of the year, which is very encouraging for the advancement of this automated activity.

The Pareto chart and its companion table presented in Fig. 5 synthesize how citations are concentrated by publication year, allowing us to identify the few years that explain most of the total impact and to distinguish “high-impact cohorts” from more recent or less-cited cohorts in the corpus.

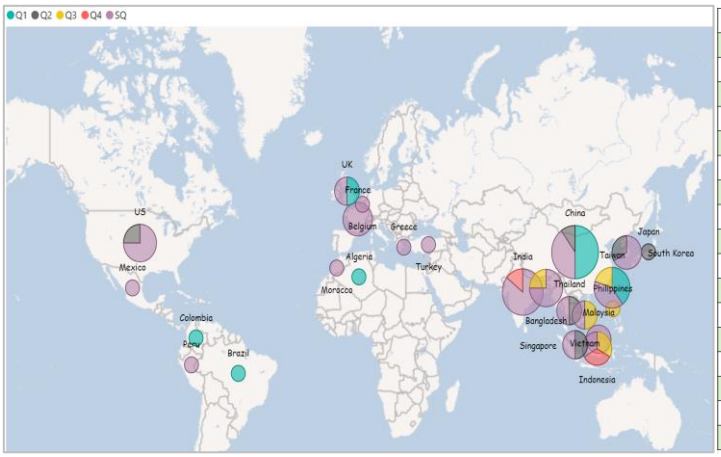
The data indicate that the citation distribution, 2019 concentrates the largest share (530 citations; 30.0% Pareto), likely because it captures early, widely adopted IoT-aquaculture implementations that became foundational references and had enough time to accumulate citations. According to the reported values, 2019–2020 already account for 52.9% of total citations, suggesting a rapid consolidation phase where a small set of studies set technical baselines (sensing, connectivity, and monitoring pipelines) that later works repeatedly cite.

According to the observed concentration, 2017 exhibits the highest citations per paper (87), which is consistent with a “pioneer effect”: fewer papers but more novelty or methodological primacy, making them disproportionately citable. As shown in the results, the post-2020 drop (especially 2021–2023) plausibly reflects a combined mechanism of citation-lag (recent papers have had less time to be cited) plus pandemic-related constraints that reduced field deployments and slowed diffusion, thereby lowering immediate scholarly uptake. According to the Pareto curve, reaching 92.2% by 2022 indicates that the research influence is strongly path-dependent: later papers often build incrementally on the 2017–2020 core rather than redefining the field’s main citation anchors.

This concentration implies that future research and practice should explicitly benchmark against the 2017–2020 “core” to ensure comparability (metrics, experimental protocols, and deployment contexts), while also designing longitudinal evaluations so newer contributions can demonstrate impact beyond citation-lag. The pattern is transferable to other sectors (e.g., smart manufacturing, logistics, energy utilities, and healthcare monitoring), where early reference architecture similarly dominates citations; replicating multi-year, multi-site validations in different geographies (Asia, Latin America, Africa, Europe) can reduce context-bias and improve generalizability.

Finally, for subsequent time windows (post-2023), prioritizing open datasets, shared evaluation pipelines, and cross-domain pilots would accelerate diffusion and mitigate the over-reliance on a small historical citation cohort.

In order to understand the distribution and breadth of research, an analysis of scientific production by bibliographic source in a specific field of study has been carried out. This allows identifying the most prolific and relevant sources, as well as assessing the impact and influence of each source on the scientific community. For the different graphs and tables, a rigorous process of data collection and analysis was carried out that covers a wide set of relevant bibliographic sources in the field. Fig. 6 shows the distribution of studies published by bibliographic sources.



Country	Q1	Q2	Q3	Q4	NQ	Total
China	5	1	0	0	4	10
India	0	0	0	1	6	7
Taiwan	2	0	1	0	2	5
Bangladesh	0	0	1	0	3	4
US	0	1	0	0	3	4
France	0	0	0	0	3	3
Indonesia	0	0	1	1	1	3
South Korea	0	1	0	0	2	3
Malaysia	0	0	0	0	2	2
Singapore	0	1	0	0	1	2
Thailand	0	1	0	0	1	2
UK	1	0	0	0	1	2
Vietnam	0	0	1	0	1	2
Algeria	1	0	0	0	0	1
Belgium	0	0	0	0	1	1
...	...	...	...	...	...	...
Total	11	6	5	2	36	60

Fig. 7. Distribution of publications by countries and quartiles

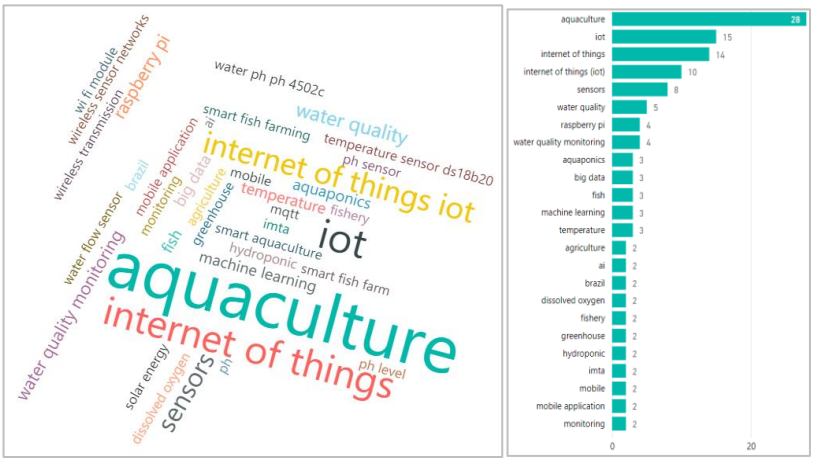


Fig. 8. Cloud of most used keywords in research titles

IEEE Xplore is the most prominent source, representing 50% of the papers. This suggests that it is a leading platform for publication in the field relevant to the study. Scopus contributes 28.3% of the papers, indicating that it is also an important source for academic literature in the area. Science Direct has only 3.3% of the papers, suggesting it is a less used source for publications in this specific field.

The strong presence of IEEE Xplore could imply that researchers prefer this platform, possibly due to its relevance, editorial quality, or focus on specific disciplines. The diversity of databases reflects that research is disseminated through various channels, which is positive for accessibility and reach. The low representation of Science Direct could indicate potential for increasing its coverage and appeal to authors in this field of study.

Table 6 summarizes the distribution of papers by institutional affiliation and bibliographic source, enabling the identification of the main centers of scientific production and the predominant dissemination channels in IoT-based aquaculture research. As observed in the results, IEEE Xplore concentrates 44 records (≈41.1%), confirming the strong engineering orientation of the field and the preference for specialized IoT repositories. According to the findings shown, Scopus contributes 29 publications (≈27.1%),

Table 6. Number of papers by affiliation and source

Affiliation	Google Scholar	IEEE Xplore	Science Direct	Scopus	Total
China Agricultural University	0	2	0	3	5
Easy Global Market	0	5	0	0	5
Jeju National University	5	0	0	0	5
National Kaohsiung University of Science	0	3	0	2	5
University of Guelma	5	0	0	0	5
North South University	0	1	0	3	4
Seattle University	0	2	0	2	4
Tatung University	0	0	4	0	4
University of Essex	0	0	0	4	4
Florida Atlantic University	0	0	0	3	3
Netas, Telekomunikasyon Anonim S,irketi	0	3	0	0	3
Sao Paulo State University	3	0	0	0	3
Shandong University of Technology	3	0	0	0	3
University Malaysia Terengganu	3	0	0	0	3
Agricultural University of Athens	0	0	0	2	2
…	…	…	…	…	…
Total	28	44	6	29	107

Table 7. Quartiles of publications on IoT monitoring and its impact on aquaculture

Quartile	2017	2018	2019	2020	2021	2022	2023	Total
UQ	4	3	14	8	4	1	2	36
Q1	0	0	2	1	1	4	3	11
Q2	0	0	0	1	2	1	2	6
Q3	0	0	0	0	1	1	3	5
Q4	0	1	0	0	1	0	0	2
Total	4	4	16	10	9	7	10	60

evidencing its role as a high-visibility multidisciplinary database. Based on the observed distribution, Google Scholar gathers 28 records (≈26.2%), reflecting broad coverage rather than thematic specialization. ScienceDirect shows only 6 papers (≈5.6%), suggesting weaker alignment with the technological core of the domain. Moreover, the cumulative total (107) exceeding the 60 unique studies confirms cross-indexing across databases, highlighting the need for rigorous bibliographic deduplication.

These findings indicate that database selection conditions the perceived scientific leadership, a pattern transferable to sectors such as digital health, Industry 4.0, and intelligent logistics. Geographically, reliance on technical repositories may bias the visibility of regions with lower IEEE presence, thus multi-database strategies are

Table 8. Number of citations by author and year

Authors	2017	2018	2019	2020	2021	2022	2023	Total
Ferrag, Mohamed Amine Shu, Leí Yang, ...	0	0	0	251	0	0	0	251
Shi, Xiaojie An, Xingshuang Zhao, Qingxu..	0	0	246	0	0	0	0	246
Encinas, Cesar Ruiz, Erica Cortez, Joaquín...	162	0	0	0	0	0	0	162
Raju, K. Raghu Sita Rama Varma, G. Hari...	143	0	0	0	0	0	0	143
Huan, Juan L¡, Huí Wu, Fan Cao, Weijian	0	0	0	92	0	0	0	92
Abraham, Shiny Shahbazian, Armand Da...	0	0	0	0	0	88	0	88
Gao, Guandong Xiao, Ke Chen, Miaomiao	0	0	78	0	0	0	0	78
Saha, Sajal Hasan Rajib, Rakibul Kabir, S…	0	62	0	0	0	0	0	62
Devi Kotha, Harika Mnssvkr Gupta, V.	0	54	0	0	0	0	0	54
Dupont, Charlotte Cousin, Philippe Dupo...	0	47	0	0	0	0	0	47
Abinaya, T. Ishwarya, J. Maheswari, M.	0	0	38	0	0	0	0	38
Lafont, Máxime Dupont, Samuel Cousin,...	0	0	34	0	0	0	0	34
Kim, Yuhwan Lee, Namgu Kim, Byeongj...	0	32	0	0	0	0	0	32
Abraham, Shiny Beard, Joshua Manijacob...	30	0	0	0	0	0	0	30
Khaoula, Taji Abdelouahid, Rachida Ait E...	0	0	0	0	29	0	0	29
Tolentino, Lean Karlo S. De Pedro, Cellin...	0	0	0	0	25	0	0	25
Ezzahoui. Ibtissame Abdelouahid. Rachid...	0	0	0	0	22	0	0	22

recommended for future reviews. Over time, shifts in indexing policies and IoT adoption may redistribute scientific output, making continuous bibliometric monitoring essential for strategic decision-making.

3.2 Answers to the Research Questions

This section presents the answers to the research questions, together with the related discussion and implications for future research.

3.2.1 RQ1: In Which Quartiles are the Research Studies that Address the Influence of IoT-Based Monitoring Within the Realm of Fish Farming Classified?

Table 7 presents the quartiles of publications related to IoT monitoring and its influence on aquaculture, organized by year. It is important to note that the quartiles mentioned in this section correspond to the classifications obtained from Scopus using the SCImago Journal Rank (SJR) tool, which organizes journals into Q1, Q2, Q3, and Q4 based on their impact.

The Unranked Quartile (UQ) has the highest number of publications, totaling 36. This suggests that many publications are not classified in traditional quartiles, which may indicate a new or emerging research area, or variability in perceived quality. There is a notable increase in Q1-classified publications from 2019 to 2023, which could indicate an improvement in the quality or relevance of research in the area. Quartile Q4 has fewer publications, which may reflect a lower number of mid-range journals or papers that fall into this category. A change in publication trends over time is observed, with a peak in 2019 and then a more balanced distribution among the quartiles in the following years.

The increase in Q1 publications implies a growing focus on research quality, which could attract more researchers and funding to the field. The change in publication trends suggests that the

field of IoT monitoring in fish farming is evolving and maturing.

Fig. 7, through a georeferential map, presents the number of papers by country and quartile. The figure was generated using the RAj research assistant, which integrates Data Science, NLP, Generative AI, Python, the ChatGPT API, and Power BI to efficiently process large volumes of bibliographic data and classify them for visualization and analysis.

The distribution suggests that China leads with 10 papers, including 5 in Q1, highlighting its strong presence in high-impact publications, followed by India with 7 papers and significant contributions to technological research. Countries such as Taiwan, Bangladesh, and the United States have intermediate representation with 4-5 papers, though with a less balanced distribution across quartiles compared to China.

In contrast, countries with fewer publications, such as Belgium, Algeria, and Vietnam, are mostly represented in lower quartiles or unranked (UQ). The majority of publications (36) are unranked (UQ), indicating that many studies are published in emerging or lower-impact journals. However, the significant number of articles in Q1 (11) and Q2 (6) suggests a trend towards publishing in higher-quality journals, especially in countries like China and Taiwan.

Finally, the absence of representation from South America is notable, emphasizing the need to promote research on IoT applied to aquaculture in this region.

From the systematic review papers mentioned above, none perform an analysis of the quartile levels of the various bibliographic sources. However, some of these papers do apply exclusion criteria and focus on analyzing the content of the selected papers.

The results demonstrate that the quartile is an indicator of the importance of an academic journal in a specific field. If a publication is classified as Q1, it is generally considered high-quality and has a greater impact on the academic community compared to publications in lower quartiles. This means that papers published in Q1 journals are usually more influential and better positioned in the field of research.

Table 9. Number of papers by country and source

Country	Google Scholar	IEEE Xplore	Science Direct	Scopus	Total
China	3	3	0	6	12
India	1	6	0	0	7
Taiwan	1	2	1	1	5
US	0	2	0	3	5
Bangladesh	0	3	0	1	4
Indonesia	2	1	0	1	4
…	…	…	…	…	…
Total	18	35	3	22	78

3.2.2 RQ2: What Keywords Appear Most Frequently in Academic Works that Focus on the Use of IoT Technologies for the Supervision of Fish Farming Activities?

Fig. 8 provides a visual representation showing the most frequently used keywords in the papers that were reviewed. These keywords are indicative of the most relevant themes and findings in the academic literature related to IoT monitoring in fish farming. The figure was also generated using the RAj research assistant, developed by Dr. Javier Gamboa-Cruzado.

The most frequent keywords are "aquaculture" (28 mentions), "iot" (15 mentions), and "internet of things" (14 mentions), reflecting the focus on the integration of IoT in fish farming as a central theme of this interdisciplinary research. The coexistence of synonyms such as "iot" and "internet of things" suggests the need for greater terminological uniformity. Technical terms like "sensors" (10 mentions) and "water quality" (5 mentions) highlight their relevance in monitoring and management, while "raspberry pi" (4 mentions) and "ph sensor" (3 mentions) reflect the use of accessible technologies. Additionally, "big data," "machine learning," and "ai" (3 mentions each) indicate a growing interest in advanced technologies, and "aquaponics" (3 mentions) broadens the scope toward sustainable systems. Lastly, terms such as "water quality monitoring" (4 mentions) and "dissolved oxygen" (2 mentions)

emphasize the focus on environmental sustainability, which is key to modern fish farming.

These findings highlight that research on IoT applied to fish farming not only focuses on monitoring and controlling key parameters but also encompasses the integration of emerging technologies such as big data and machine learning to enhance the sector's efficiency and sustainability. Furthermore, they reflect the need for an interdisciplinary approach that combines technology, sustainability, and agriculture.

3.2.3 RQ3: Which Researchers have Contributed Most Extensively and Which are the Most Prominent Nations in the Field of Study of the IoT Impact on Fish Farming Management?

To answer the question, Table 8 has been prepared, showing the number of citations per author and year, between the years 2017 and 2023.

Note: The citations listed in the table represent the total cumulative citations for each article, grouped by the year of publication. This does not indicate the year in which those citations were made.

The authors with the highest number of citations are Ferrag, Mohamed Amine Shu, Lei Yang, Xing D. with 251 citations, followed by Shi, Xiaojie An, Xingshuang Zhao, Qingxue Liu with 246 citations, and then Encinas, Cesar Ruiz, Erica Cortez, Joaquín E. with 162 citations. The variability in the number of publications year by year for different authors indicates fluctuations in research productivity, possibly due to research project cycles, changes in funding, or specific collaborations. Authors such as Abraham, Shiny and Gao, Guandong, who started publishing in recent years (2022 and 2019, respectively), possibly represent the emergence of new researchers or fields of study. Authors such as Encinas, Cesar and Raju, K. Raghu, who published in 2017 but not in subsequent years, may indicate a decrease in research activity or a shift in their areas of focus.

The provided data allows for several implications. The concentration of publications in certain years could be influenced by global trends, significant events in the field of study, or worldwide occurrences such as the Coronavirus Disease 2019 (COVID-19) pandemic. The analysis of publication activity could be useful in identifying potential collaborators based on their periods of highest activity and specialization. The table can serve as an indicator of academic career development, showing how some researchers emerge while others may be decreasing their production. Finally, trends in the number of publications could reflect the health and dynamism of specific fields of study, indicating areas of growth or decline.

Table 9 shows the number of papers by country and bibliographic source.

China and India lead in the number of published papers, with 12 and 7 respectively. This indicates a strong presence in academic research in these countries. Other nations also contributed significantly. The United Kingdom contributed 4 papers, followed by France, South Korea, and Vietnam with 3 papers each. Countries such as Brazil, Greece, Ireland, Malaysia, Saudi Arabia, Singapore, and Thailand contributed 2 papers each. Finally, Algeria, Belgium, Canada, and Ghana contributed 1 paper each. Papers from China are relatively evenly distributed among Google Scholar, IEEE Xplore, and Scopus, while India has a notable preference for IEEE Xplore. IEEE Xplore and Scopus contain most of the listed papers (35 in IEEE Xplore and 22 in Scopus), suggesting their importance as a source of academic publications in these fields.

In the systematic literature review conducted by Bernal-Higuita and collaborators [9], the most cited studies on IoT sensors for water quality were analyzed, and Saha and colleagues [45] and Chuyen and coauthors [14] were identified as prominent contributors in this area.

A geographical diversity in academic research is reflected, with contributions from countries in Asia and North America. It is crucial to know the relevant authors, countries, and publications to analyze the trends and the importance given to this activity and technology. The significant number of publications from China and India suggests a strong focus and possibly substantial investment in research and development in these countries. This could reflect a national strategy to advance in science and technology. The dominance of IEEE Xplore and Scopus in the total number of publications highlights their importance in the

Table 10. Criteria for evaluating fish farming with IoT

Criterion	Reference	Qty. (%)
Type of IoT sensors used	[1][2][3][4][5][6][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][56]	51 (15.36)
Data collection methods used	[1][2][3][4][5][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][56]	50 (15.06)
Data analysis methods used	[2][4][5][8][10][11][13][15][16][17][18][19][20][25][29][31][32][33][34][35][36][37][39][40][41][42][43][44][45][47][48][49][50][51][52][56][60]	37 (11.14)
IoT platform used	[2][4][5][8][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][56][60]	47 (14.16)
User interface of the IoT platform	[2][4][5][8][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][39][40][41][42][43][44][45][47][48][49][50][52][60]	43 (12.95)
Cost of the IoT system	[41]	1 (0.30)
Scalability of the IoT system	[1][2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][56][58][59][60]	54 (16.27)
Sustainability of the IoT system	[2][4][5][8][10][11][12][13][14][15][16][17][18][19][20][21][22][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][56][58][59][60]	49 (14.76)

dissemination of scientific knowledge. These platforms could be crucial for researchers seeking international visibility and recognition. The presence of several countries in research indicates a diverse geographical contribution to global knowledge. This opens opportunities for international collaborations and the possibility of enriching research through different cultural and methodological perspectives.

3.2.4 RQ4: What are the Criteria Used to Evaluate Fish Farming Through IoT Monitoring?

Table 10 presents the percentage of application of the criteria used to evaluate fish farming through IoT. Eight general criteria common to all analyzed publications have been identified.

The scalability of the IoT system is the most mentioned criterion (16.3%), indicating the importance of systems that can adapt to different scales of operation in fish farming. The types of IoT sensors and data collection methods also receive a lot of attention (15.4% and 15.1% respectively), highlighting the need for precise and efficient technology to collect relevant data in fish farming. The sustainability of the IoT system, mentioned in 14.8% of the references, reflects a growing awareness of the importance of environmentally sustainable and low-impact systems. Data analysis methods are an important criterion (11.1%), indicating the need to effectively interpret the collected data for informed decision-making in fish farming. The cost of the IoT system is the least mentioned criterion (0.3%), which could suggest a lesser concern for economic aspects compared to the functionality and effectiveness of the system.

In the systematic literature review publications of this study, the authors do not specifically address the question regarding the criteria used to evaluate fish farming with IoT. However, they emphasize IoT technologies and their applications in the context of aquaculture. Desai and colleagues [18] conducted a study focused on the main parameters that should be measured in water quality for IoT-based monitoring. These parameters include pH, temperature, turbidity, dissolved oxygen, electrical conductivity, among others, listed in that order of importance.

It is certainly important to identify the study criteria used in different publications, as this information provides us with a deeper understanding of the specific approaches of each

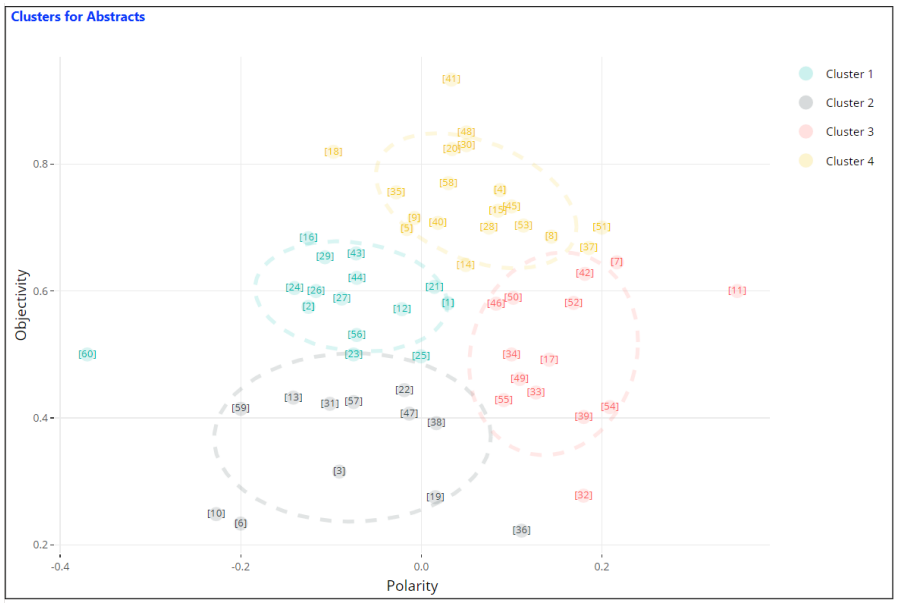


Fig. 9. Paper cluster by polarity and objectivity of their abstracts

research and how IoT technology is implemented in fish farming activities. These criteria allow us to evaluate the quality and relevance of the studies and can also serve as a reference for future research in the field. The high mention of scalability implies the need for IoT systems that can be easily adapted for different sizes and types of operations in fish farming. The focus on sensors and data collection methods suggests a fertile field for technological innovation, aiming to improve efficiency and precision in fish farming. The importance given to sustainability and user experience highlights the need for IoT systems that are environmentally responsible and user-friendly, which can encourage their adoption and effectiveness. The low mention of cost suggests that economic viability may be underestimated in the current literature, which is crucial for the widespread adoption of these systems.

3.2.5 RQ5: Which Publications, Focused on the Research of fish farming through IoT, present abstracts with a high degree of objectivity and minimal biased tendency?

In Fig. 9, the 60 selected papers have been divided into 4 clusters based on their characteristics of polarity and objectivity in the abstracts. Each cluster represents a group of papers that share similarities in how they express themselves in their abstracts.

It is important to analyze in detail the papers of each cluster to understand how they differ in terms of objectivity and polarity in their abstracts. This can provide valuable information about the trends and approaches in research on IoT monitoring in fish farming and how this information is presented in the paper abstracts.

The papers grouped in Cluster 4 (19 yellow points) are situated in the area of high objectivity and moderate polarity. This suggests that these papers present their abstracts in a neutral and fact-based manner, with a less subjective or emotional tone. Cluster 2 (12 gray points) seems to have lower polarity and lower objectivity. The concentration of points at the top of the graph indicates a general trend towards objectivity in the paper abstracts, which is desirable in scientific writing.

Cluster 3, represented by 14 red points in the figure, is characterized by a group of articles located in an area of moderate to high polarity and relatively high levels of objectivity, although not as elevated as those in Cluster 4. From the analysis of this question, it emerges that papers with high objectivity and low polarity, as identified in Cluster 1 (15 green points), are likely to be perceived as

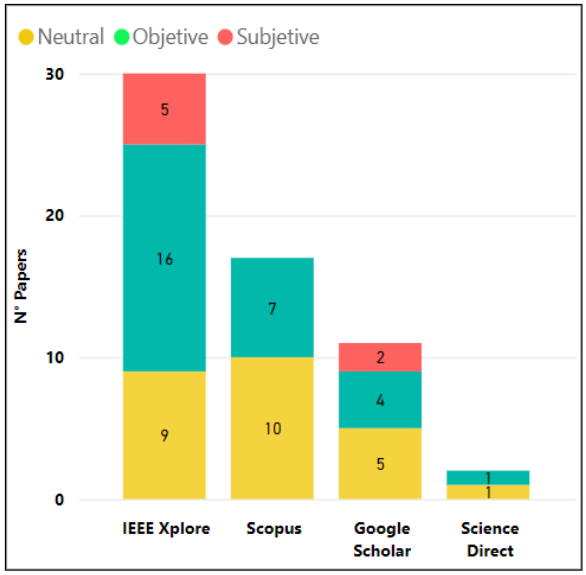


Fig. 10. Number of papers according to the objectivity of their abstracts by Source

more trustworthy and of higher quality by the scientific community, as they reflect a data-based and unbiased analysis approach.

For researchers looking to publish in the field of IoT monitoring in fish farming, there is a clear indication that objectivity is valued. Therefore, they should strive to maintain a neutral tone and present their findings objectively.

Fig. 10 shows the number of papers classified by the objectivity of their abstracts grouped by source. It stands out that the main source of these papers is IEEE Xplore, and these papers tend to have more objective content compared to other sources. This suggests that IEEE Xplore may be an important source for finding objective research on IoT monitoring in fish farming.

IEEE Xplore shows a predominance of objective papers, with a significant number of neutral papers and few subjective ones. Scopus has a more uniform balance between neutral and objective papers, with no subjective papers. Google Scholar presents a larger number of neutral papers compared to objective and subjective ones.

Science Direct has a limited number of papers and a greater focus on objective papers. Papers from IEEE Xplore and Science Direct tend to be more objective compared to those from Scopus and Google Scholar.

It is interesting to note that in other similar systematic reviews, the question of the objectivity and polarity of paper abstracts has not been specifically addressed. Instead, these reviews have emphasized the quantity of certain elements of IoT technology in fish farming activity.

This highlights the uniqueness of your research in exploring different aspects of the selected papers, such as their writing style and tone in the abstracts.

From the analysis of this question, it emerges that the high proportion of objective papers in IEEE Xplore and Science Direct could imply greater trust and usefulness for researchers seeking factual and detailed information. This information is valuable for understanding the quality and objective focus of research in these specific sources. Researchers may prefer IEEE Xplore and Science Direct when looking for papers with a more objective tone, while Google Scholar could be useful for obtaining a variety of perspectives and approaches.

4 Conclusions and Future Research

This systematic literature review analyzed 60 papers focused on IoT monitoring in aquaculture. These studies were selected from specialized database s following strict and well-defined criteria. The results obtained from this comprehensive review have been significant, providing substantial answers to the research questions posed at the beginning of the study. Furthermore, these findings offer a valuable and in-depth perspective on the subject of study, enriching the current understanding of the role of IoT in aquaculture and its various implications. This review has proven to be a crucial resource for gaining a more complete and up-to-date understanding of this evolving area of research.

By addressing the research questions posed in this systematic literature review on IoT monitoring and its impact on fish farming, the following results were obtained: For RQ1, which referred to the quartile levels of the publications, it was found that the majority of the 60 reviewed papers did not have an assigned quartile (36), 11 papers were in the first quartile (Q1), and 6 papers were in the second

quartile (Q2). Regarding RQ2, which investigated the most used keywords in the publications, the most recurrent keywords were identified. In the titles, the words "aquaculture" (40 repetitions) and "system" (35 repetitions) were the most common, followed by "iot" (33 repetitions) and "monitoring" (27 repetitions).

For RQ3, which focused on the most productive authors, countries, and publications, the authors with the most contributions were identified, with Ferrag Mohamed and Shi Xiaojie An standing out with 251 and 246 citations, respectively. China led in terms of the number of publications with 12, followed by India with 7 and Taiwan with 5. The most productive bibliographic source was IEEE Xplore, and the publication with the most citations was the 2019 Global IoT Summit (GloTS).

RQ4 addressed the criteria used to evaluate fish farming with IoT. The criteria included the type of IoT sensors used, data collection methods, data analysis methods, the IoT platform used, the user interface of the IoT platform, the cost of the IoT system, the scalability of the IoT system, and the sustainability of the IoT system. The least addressed criterion in the research was the cost of the IoT system.

Finally, RQ5 focused on the objectivity and polarity of the research abstracts. A cluster analysis was conducted that grouped the abstracts into four distinct categories. The analysis suggests that IEEE Xplore showed higher objectivity levels compared to other sources. The results demonstrate the utility of sentiment analysis tools for classifying and evaluating scientific literature, which can be useful for systematic review and meta-analysis.

They provide a comprehensive view of research on IoT monitoring in fish farming and help to better understand the current state of this field of study.

From this systematic review, several opportunities for future work in IoT applied to fish farming have been identified. These include analyzing the socioeconomic and ecological impact, developing standards for IoT sensors, and researching scalable and adaptable solutions for regions with limited resources. It is also relevant to explore emerging technologies such as AI and ML, applications in aquaponic systems, and the comparison of regional approaches to overcome technological and cultural barriers. In addition, future studies could explore multimodal sensing architectures that combine IoT devices with computer vision, hyperspectral imaging, and advanced analytical models to strengthen water-quality assessment, contaminant detection, traceability, and early risk identification. These directions hold significant promise for advancing the sustainability, efficiency, and accessibility of IoT-assisted fish farming.

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