

# Employing Artificial Intelligence in the Development and Security of Aquaculture

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## Abstract

This research paper aims to shed light on the role of artificial intelligence (AI) applications in improving and developing aquaculture. AI and technological applications are among the most effective methods for mitigating the adverse effects of various risks, such as pollution and diseases, that may threaten aquaculture farms and investments. By enhancing the quality of aquatic products and improving the production process, AI not only supports the economy but also ensures the safety and quality of the food supply, thereby achieving food security. This is accomplished by providing AI equipment, tools, and protection for this type of investment. Various technological applications work to reduce production costs and encourage investment in aquaculture. However, there are challenges to implementing AI, including data collection, a lack of technical and financial support, and insufficient control over algorithms and self-learning techniques by farmers and investors, especially in developing countries.

**Keywords:** *Aquaculture; Artificial Intelligence ; Insurance ; Technology.*

## INTRODUCTION

The use of artificial intelligence applications to improve, develop and secure aquaculture cultivation is one of the biggest challenges that all countries may face, most of which have worked to implement economic and financial programs and policies that help promote the field of aquaculture and raise the production of fish, crustaceans, molluscs and marine plants, and provide them in significant quantities in local and international markets, but this agricultural field faces severe fluctuations at the productive level due to its exposure to many dangers, including the breakdown of farming machines such as pumps, measuring devices and temperature adjustment. . etc., including those related to natural disasters, as this agriculture is practiced in places often open and is affected by natural factors such as frost, extreme heat, drought, storms, pest infestation, diseases, pollution... etc. which threatens production and the expected return from it, which leads to a decrease in incomes for producers and may push some of them out of this field.

To address this problem and find the means that would protect such types of investments, various mechanisms have been adopted in the management of these risks, and insurance is considered one of the most influential and best ways to reduce the adverse effects of these risks, and this is by compensating investors or farmers for losses that affect their farms, and this by employing artificial intelligence techniques in all insurance and agricultural activities.

Through this paper, we will try to answer the following question:

### **How do AI applications contribute to supporting and securing aquaculture agriculture?**

- **Hypothesis:**

**H1:** Artificial intelligence contributes to the development and improvement of aquaculture

**H2:** Technologies adopted in artificial intelligence are used in the insurance activity of aquaculture.

- **Study Objective:**

The importance of this research paper is to highlight the role and importance of artificial intelligence in the development and improvement of aquaculture cultivation at all stages of breeding, as well as the employment of artificial intelligence in insurance, whose seeds support and encourage investors farmers to work in this agriculture, as technology associated with artificial intelligence works to increase the productive capacity in aquaculture agriculture, raise the quality of production, and reduce costs, which ensures and helps to achieve better agricultural results in this field and encourage investment in it.

- **Themes of the study:**

This study is divided into five axes as follows:

**Axis 1:** The concept of artificial intelligence and aquaculture.

**Axis 2:** The importance of artificial intelligence in the development of aquaculture

**Axis 3:** Employing artificial intelligence techniques in improving insurance operations

**Axis 4:** Insurance and aquaculture risks

**Axis 5:** Challenges of adopting AI in supporting and securing aquaculture

## **1. The concept of artificial intelligence and aquaculture**

### **1.1. Definition of artificial intelligence:**

Artificial intelligence is a type branch of computer science that is concerned with the study and formation of computer systems that show some forms of intelligence, and these systems have some forms of intelligence, and these systems can make beneficial conclusions about the problem developed as these systems can understand natural languages or understand living perception and other possibilities that need intelligence when implemented by humans (Hajira, 2018) Artificial intelligence is also the set of theories and technologies used to produce machines capable of simulating human intelligence, using powerful algorithms to provide practical, reliable, and customized answers to users by combining hardware and software. Artificial intelligence mobilizes interdisciplinary knowledge in electronics, computer science, and mathematics. (CEA, 2017).

**1.2. Characteristics of artificial intelligence:** Through its applications, artificial intelligence entered limitless fields, and therefore, it had distinct characteristics as follows (faithful, Hajar, & Afif, 2019)

- The use of artificial intelligence to solve the problems presented;
- The ability to think, learn, perceive, acquire and apply knowledge, and use old experiences and employ them in new situations;

- The ability to use trial and error to explore different things and respond quickly to new situations and circumstances;
- The ability to deal with difficult and complex situations and ambiguous situations, even in the absence of information;
- The ability to discern the relative importance of the elements of the situations presented and to be able to visualize, create, understand, and perceive the visual;

**1.3. Artificial Intelligence Systems:** Artificial intelligence systems include the following (faithful, Hajar, & Afif, 2019)

- **Expert systems:** These are complex computer systems based on collecting specialized information from human experts and placing them in a form that enables the computer to apply that information to similar problems.
- **Neural networks:** An artificial neural network is a system for processing data like a natural neural network of a person or organism. It contributes to finding highly efficient solutions in many areas, including image recognition, identifying suspicious images, and completing images that have lost part of them.
- **Genetic algorithm systems:** This technique is based on the practical idea of a computerized program in which possible decision solutions compete. It is also used in financial and banking, logistics operations, and material movement control.
- **Fuzzy logic systems:** One of the growing applications of artificial intelligence in business, fuzzy logic systems deal with vague, undefined, and probabilistic data using justification that resembles human justification, which allows inference based on them, such as in weather forecasts.
- **Smart agent:** It is one of the applications of data mining from the Internet or Internet databases. It works through a software package that performs specific tasks or duties of a repetitive or predictive nature for the beneficiary. The electronic administration uses intelligent agents to respond to customer messages, respond to their requests, and hear their opinions about the quality of services.
- **Robotics:** Robotics are mechanical and flexible devices that hold and transport materials. They carry out work and tasks that are dangerous to human life and are characterized by accuracy, speed, and strength.
- **Natural language processing:** It is a sub-science of artificial intelligence, which in turn is a branch of informatics and overlaps significantly with linguistics that provides the required linguistic description of the computer and is used in many fields such as the automatic reading of texts, text generation or automatic speech, translation techniques, and text revision.

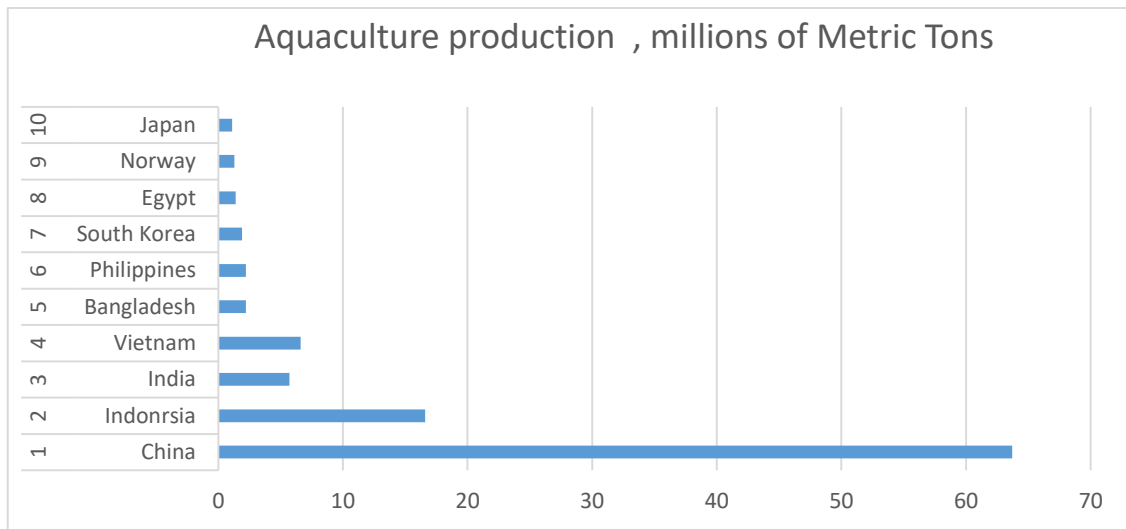
**1.4. Definition of aquaculture:** Aquaculture includes fish, shellfish, crustaceans, and aquatic grasses. Its activity includes human intervention in the care process to improve production, regular storage, nutrition, and protection from predators. Aquaculture also includes the individual or joint ownership of the stock under culture.

Legal aquaculture is an activity for the cultivation of aquatic species whose ownership belongs to the legal person identified throughout the saline and freshwater cultivation cycle, and the activities of processing, packaging, and marketing aquaculture products (animals and

plants) owned by a legal person, are characterized by specific characteristics that distinguish them from fishing. (universalis).

**1.5. Reasons for interest in aquaculture:** Some of them can be mentioned in the following points (Report of the Food and Agriculture Organization of the United Nations, 2014)

- **1A chieving food security:** In a world where more than 800 million people suffer from chronic malnutrition, where the population is expected to grow by two billion people to reach 9.6 billion by 2050 with the concentration of population density in coastal urban areas, it was necessary to meet the daunting challenge of feeding the planet, eradicating hunger, promoting health and reducing poverty, especially since aquaculture remains the fastest growing food-producing sector.

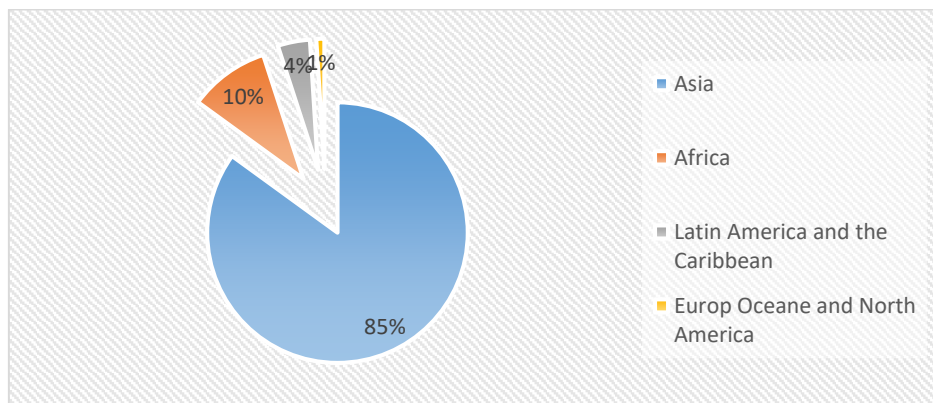


**Figure 1: Top 10 Countries for Aquaculture Production 2022**

Source: (food and agriculture organization of the united nations, 2024)

- **Job creation:** Fisheries and aquaculture are not only a source of health; the sector provides jobs for tens of millions of people and supports the livelihoods of hundreds of millions. People employed in primary production:61.8million

Workers by sector: Fisheries 54%.Aquaculture 36%. Sector not specified



**Figure 2: Percentage of jobs by region**

Source: (food and agriculture organization of the united nations, 2024)

- Boosting the economy** Global fish production increased by 1.2 % in 2022, which, combined with higher prices for several important traded species, led to a significant increase in trade value. While the growth in aquaculture was lower than previous rates, an annual increase of 2.6 % means that an additional 2.4 million tonnes of farmed fish will be produced in 2022. Capture fisheries production declined slightly to 92.1 million tonnes, with reduced catches of Peruvian anchorets having a marked impact on supply. Value of international trade in aquatic products USD 195 billion (gross, 2023)

Economically, aquaculture also revives the tourism sector by preserving and attracting tourists to freshwater and saltwater reserves, increasing the trade balance, and obtaining hard currency.

## 2. The importance of artificial intelligence in the development of aquaculture

**2.1. Artificial intelligence at the heart of the future** of aquaculture: The application of artificial intelligence in aquaculture began mainly with machine learning and neural networks for deep learning, and according to a survey, only 10% of companies established after 2010 use artificial intelligence, and in 2015 it exceeded 50% (this.fish, 2021)

Data is often called the new oil, so if algorithms are the engines, data is the fuel that drives the Fourth Industrial Revolution. From 2010 to 2020, the estimated amount of digital data on Earth increased 30 times, and this period also witnessed the launch of applications based on artificial intelligence in aquaculture (this.fish, 2021)

73% of startups in aquaculture use at least one type of sensor, half of which use cameras and algorithms, and sensors for artificial intelligence are considered wells for the oil industry, pumping vast amounts of data into the world and forming water quality sensors, cameras, satellite images, and aquacoustic devices What is known as the Internet of Things in aquaculture Using remote sensors to collect data has become more accessible and cheaper than ever, and this is in the case of aquaculture Production, fish health, water quality nutrition, mortality and maintaining water quality are also vital cost centers for farmers It is no surprise that these are the pain points that AI is trying to solve.

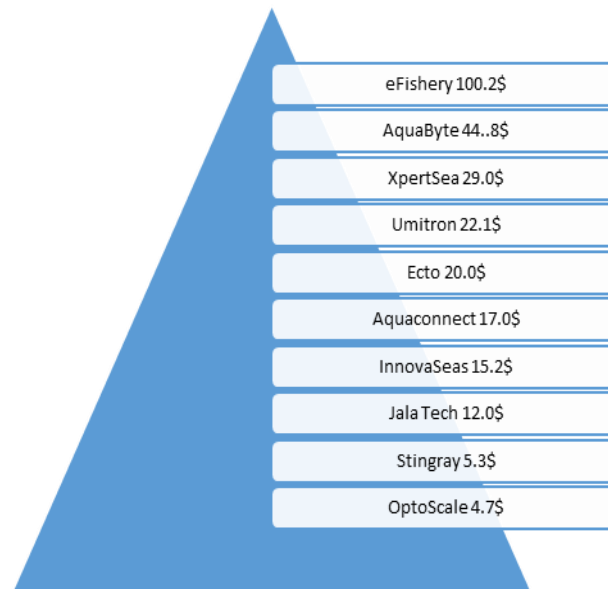
The following table provides an abbreviation of the functions of aquaculture programs.

**Table 1: Aquaculture Software Function**

Of 82 software apps for aquaculture. Here are the most common functions		
Functions	Usage ratio	Applications
Estimate biomass forecast growth	41%	
Monitor water quality	46%	
Optimize feeding and detect appetite.	34%	
Monitor health and predict disease outbreaks.	26%	
Digital and manage farm data	40%	
Cont lice on fish	6%	

Source: (Tamm, 2021)

As for the money now flowing into this sector, it is shown in the following figure.



**Figure 3: Applications of Artificial Intelligence in aquaculture**

**Source:** (Tamm, 2021)

## 2.2. Supporting artificial intelligence for aquaculture agriculture: represented in:

Sustainable aquaculture reduces the environmental impact of fish farming operations. AI can play an essential role by helping farmers monitor and manage water quality. Sensors can collect data on water temperature, pH levels, and dissolved oxygen, which AI algorithms can then analyze to identify potential trends and issues. This information can be used to adjust the farming environment, ensuring fish are raised in the best conditions while minimizing the impact on surrounding ecosystems. Conservation efforts can also benefit from AI technology.

In addition, AI can contribute to the development of more sustainable fish farming practices by helping to select suitable sites for new aquaculture facilities; by analyzing data related to ocean currents, water temperature, and other environmental factors, AI algorithms can identify the most suitable areas for fish farming while minimizing the impact on local ecosystems and integrating AI into aquaculture management and conservation revolutionizes our approach to sustainable fishing, helps AI-powered systems enable farmers to improve their operations, reduce waste and reduce its environmental impact.

At the same time, AI is critical in preserving global fish stocks by monitoring fishing activities and identifying patterns that may indicate illegal or unsustainable practices. As the demand for seafood continues to grow, adopting AI technology in aquaculture will be vital to ensuring the long-term sustainability of the industry and the health of our oceans. The technological wave of sustainable fishing is here, and it is powered by artificial intelligence (ts2.space, 2023)

Applications of artificial intelligence in aquaculture management allow depth exploration and conservation. Artificial intelligence has created waves in various industries, and aquaculture is no exception. As the demand for seafood continues to grow, the need for sustainable fishing practices may increase, and artificial intelligence has proven to be a valuable tool in helping the aquaculture industry meet this demand while reducing its

environmental impact, by monitoring fish health and improving feeding schedules (ibtekr, 2023).

### 3. Employing artificial intelligence techniques in improving insurance operations

**3.1 The contribution of artificial intelligence to improving insurance activities:** Insurance companies use artificial intelligence applications in practicing their insurance activities such as production, pricing, underwriting, compensation, and others

**Table 2: Through the following table, an explanation of the employment of ai in the insurance service and its effectiveness in improving services**

Advantages of artificial intelligence in the management of insurance services	Insurance activity
<ul style="list-style-type: none"> <li>Accelerate internal processes: One of the main benefits of AI in the insurance industry is its ability to speed up many internal processes. Automating tasks such as closing contracts or managing claims allows insurers to improve efficiency while reducing processing times. Save time that will undoubtedly translate into money!</li> </ul>	<ul style="list-style-type: none"> <li>Advanced marketing strategies.</li> <li>Advertising design and communication</li> <li>Product development and pricing</li> </ul>
<ul style="list-style-type: none"> <li>Improving customer experience: Often neglected, customer experience is critical for every company. Artificial intelligence, through historical data analysis and predictive models, will be able to customize offers according to each customer's needs and behaviors. In short, a more proactive approach to product design and more accurate pricing will build customer loyalty.</li> </ul>	<ul style="list-style-type: none"> <li>Enhance customer service.</li> <li>Develop relationships with customers.</li> <li>Classification of insurance customers</li> </ul>
<ul style="list-style-type: none"> <li>Risk prevention: undoubtedly the main advantage of artificial intelligence! Risk prevention will be a significant issue in tomorrow's world. Sophisticated AI algorithms will allow companies to detect weak signals and suspicious behavior and thus report or not report a potential risk (fraud, flood zone within a few years, etc.).</li> </ul>	<ul style="list-style-type: none"> <li>Analyze demand and create instant offers</li> <li>Raise the efficiency of the procurement process</li> </ul>
	<ul style="list-style-type: none"> <li>Improved risk assessment</li> <li>Fraud detection and prevention</li> <li>Risk mitigation</li> <li>Fair pricing</li> </ul>
	<ul style="list-style-type: none"> <li>Efficiency and speed</li> <li>Increase productivity and accuracy</li> <li>Improve customer experience</li> <li>Fraud detection</li> <li>Automatic claims sorting</li> </ul>
	<ul style="list-style-type: none"> <li>Leverage qualitative data for risk modeling</li> <li>Risk forecasting</li> <li>Real-time risk monitoring</li> <li>Investment portfolio management</li> <li>Investment decision support</li> </ul>
	<ul style="list-style-type: none"> <li>Solvency control</li> <li>Follow laws and regulations</li> <li>Reports</li> <li>Decision support</li> </ul>
	<ul style="list-style-type: none"> <li>Asset &amp; Risk Management</li> </ul>
	<ul style="list-style-type: none"> <li>Support activities and decision</li> </ul>

Source: (Samah & Bayou , 2024) (Moreover, 2023)

**3.2. The use of smart devices in insurance services:** There are many and varied smart devices used in insurance operations, for example, the following:

- Robotics: The increasing presence of robots in daily life and across industries will lead to a change in the concept of risks and the emergence of new insurance needs for customers, and the field of robotics has witnessed many exciting achievements in recent times for example, what is known as additive manufacturing or three-dimensional

printing, which will contribute to the design of commercial insurance products in the future (the experience of AXA's Emerging Customers department, 2018)

- **Smartphone and Internet (digital platform):** Users can purchase insurance policies, pay premiums, collect claims, declare accidents, and send photos, information, and videos from anywhere via their smartphones, allowing them to shorten time and reduce costs.
- **Drones:** It is a practical tool in assessing losses by insurance companies, and these drones are used to collect photographic data to determine the extent of damage (Federation, <https://www.ifegypt.org>)

#### 4. Insurance and aquaculture risks

**4.1. Diseases associated with aquaculture:** Although some fish diseases can be easily identified, such as superficial parasitic diseases and fungal diseases, many of us cannot identify many other diseases that kill fish, especially bacterial and viral diseases, and in general, fish diseases can be divided into:

- **Bacterial diseases:** Bacterial diseases spread if the conditions are right; that is, they spread in the case of crowded fish if they have wounds or scratches or if the breeding water is not suitable. In this case, the rate of fish death is high and fast,
- **Fungal diseases:** They are secondary diseases, that is, they affect fish already infected with some wounds or bacterial or parasitic diseases or bred under inappropriate conditions, and one of the most critical factors that help the spread of fungal diseases in fish is water pollution, lack of ventilation, and increase the proportion of ammonia and other toxic substances in it
- **Viral diseases:** Viruses are the smallest microscopic creatures; unfortunately, viral diseases have no cure yet. The only treatment is to burn infected fish, all the fish in the aquarium, and the aquatic plants. After that, the aquarium and its very different contents are dried, sterilized, and dried for a sufficient time, and then other new fish are placed.
- **Parasitic diseases:** Many single-celled or multicellular parasites infect fish. Some can be seen with the naked eye. They are attached to the host (fish) or embedded inside the skin, and they feed on the internal fluids of fish.

**4.2. Insurable risks in the aquaculture portfolio:** Anyone with appropriate insurance premiums can insure against almost any risk: drought, tidal waves, earthquakes, storms, lightning, diseases, water pollution, lack of oxygen, hypothermia, freezing, sudden salinity fluctuations, breakdown of machinery and electrical systems, and even explosions, and market leaders in the field of insurance cooperate with their customers to develop insurance coverages explicitly designed to ensure the best possible protection for their specific requirements, including: (Federation, <https://www.ifegypt.org>)

- **Securing marine operations:** Securing aquaculture equipment and operations abroad requires a specialized underwriting method, as the marine environment is almost always hostile at some point, and managing its risks can be difficult and costly.

In many countries, overseas operations are subject to comprehensive health and safety regulations, often affecting employers' insurance companies and workers' liability. There is a large marine insurance market that includes insurance for boats and other equipment used in



offshore aquaculture as well as associated marine responsibilities, but not the biological risks to livestock in offshore aquaculture facilities;

- **Employers' liability insurance:** particularly for overseas workers, employers' liability for divers, and the implications of aquaculture are clear. All areas of health and safety at work face a steady tightening in employment legislation and insurance costs. Aquaculture must change to meet new challenges. It should be routinely adopted for rigorous risk assessment and exposure analysis of public employment practices, in particular its diving practices, prioritizing the implementation of health and safety procedures, and civil liability insurance is a mandatory guarantee for all regulated professions;
- **Final product insurance, product liability:** As society gradually becomes more litigant, product liability and product retrieval assurance are likely to interest the aquaculture industry, especially for producers who sell in supermarket chains. Comprehensive tracing of the origin of aquaculture production is a growing demand in many countries, and there are also signs that consumers and their lawyers are closely monitoring the industry.
- **Livestock insurance (aquatic animals and plants):** One of the most challenging types of insurance is to insure livestock for farmed aquatic animals and plants. Livestock insurance in aquaculture represents many problems for the insurance industry; however, it is likely the most crucial interest in any aquaculture process.

In other words, Aquaculture insurance products can be distinguished into i) indemnity-based insurance that includes all-risk stock mortality and specifically defined named perils, and ii) index-based insurance that covers weather perils and protects gross margins.

**Table 3: overview of aquaculture insurance products**

insurance type	insurance product	insured perils	advantages	disadvantages
Indemnity-based insurance	all-risk stock mortality insurance	offshore sites * mortality due to natural perils (storm, lightning, tsunamis, freezing), accidents(collisions), predation, algal bloom, diseases, and (in some cases) epidemic diseases * damage to equipment from natural perils and flex * Optional covers for theft, malicious acts, pollution, and compromised water quality transit. onshore sites * Mortality due to natural parts (flood, earthquake, tsunamis, tidal waves), predation, diseases, and (in some cases) epidemic diseases.	* individual-listed insurance reflection site-specific conditions and standards * optional covers(mainly for industrialised producers)	* adverse selection and moral hazard * high costs for administration, distribution, and loss adjustment * little option for smallholder producers
	named peril insurance	* damage to equipment from natural perils, flex, equipment failure ( mechanical breakdown,		

		<p>electrical interruption, breakages of the water supply system)</p> <ul style="list-style-type: none"> <li>* Optional covers for theft, malicious acts, pollution, compromised water quality, and transit.</li> </ul> <p>Market-specific covers</p> <ul style="list-style-type: none"> <li>* incurred costs for vaccination .disinfection. destruction of stock</li> <li>* aspects of business interruption from government-ordered slaughter (epidemic diseases)</li> </ul>		
index-based insurance	weather insurance	<p>adverse weather conditions, including</p> <ul style="list-style-type: none"> <li>* high temperature (e.g., heat days)causing changes in oxygen levels in the water ( onshore)</li> <li>* low temperature causing changes in oxygen levels and freeze of stock ( offshore and onshore )</li> <li>* excessive rainfall ( flash floods) causing stock disappearance ( onshore)</li> </ul> <p>high wind speed causing overthrowing of cages ( offshore)</p>	<ul style="list-style-type: none"> <li>* limited adverse selection and moral hazard</li> <li>* fast pay-outs</li> <li>* low costs for loss adjustment</li> </ul>	<ul style="list-style-type: none"> <li>* basis risk</li> <li>* reputation risk for insurer</li> <li>*concept and indices challenging to understand for operators</li> <li>* high costs for weather data (depending on country)</li> </ul>
	revenue insurance	<p>volatility in gross margins from</p> <ul style="list-style-type: none"> <li>* prices of aquaculture products and</li> <li>* Costs for feed include high components of publicly traded grain and oilseed commodities.</li> </ul>	<ul style="list-style-type: none"> <li>* covers gross margins of operator</li> </ul>	<ul style="list-style-type: none"> <li>* basis risk</li> <li>* high development costs</li> </ul>

Source: (Roman Hohl, 2021)

### 5. Challenges of adopting artificial intelligence in supporting and securing aquaculture:

The applications provided by artificial intelligence to develop and produce aquaculture suffer from the problem of lack of familiarity with machine learning solutions, and among the challenges facing artificial intelligence are the following: (cisin, n.d.)

**5.1. Lack of support:** This challenge hinders the development of artificial intelligence, and this happens because many people do not know what artificial intelligence is. They do not understand how to use a machine capable of thinking and learning independently. The rejection it faces from people prevents it from progressing and achieving new horizons of development. Now that people do not demand it, there is no demand for it in the market, and as a result, companies or organizations are not also investing in AI at the time, and that is how they face a lack of support.

**5.2. Weak trust on the part of farmers and traditional investors in AI applications:** Just as the name suggests, it is a kind of intelligence but inhumane. This raises doubts among people about the machine's ability to make decisions, and it is not as simple as a banking procedure where you can show math algorithms and understand the customer or at least gain the customer's trust. The procedure is more complicated than artificial intelligence and challenging to explain to the general public. Hence, people do not trust this easily but are left alone to

accept, in addition to the weakness and lack of opportunities for innovation and investment due to the socio-economic environment that depends on the import of technology.

**5.3. vulnerable to violations:** Machine learning and artificial intelligence systems rely heavily on the data they obtain. For better performance, this data is often personal and sensitive. This is what makes them vulnerable to theft and breaches, and such types of breaches have become very common nowadays after rules and regulations were put in place to create and develop such types of artificial intelligence that do not pose any threat to a person's data, its confidentiality, security, etc. This is designed for machine learning systems and AI applications because they store many inherently sensitive data.

**5.4. Climate diversity and external factors:** It is difficult to predict their results cause damage to equipment and crops, as well as the failure of artificial intelligence systems and the reluctance of farmers and investors to insure, except for compulsory insurances that are imposed by force of law, especially in countries that see commercial insurance as additional expenses, and therefore in the event of machinery breakdown and crop damage, farmers find themselves alone in bearing the losses they suffer.

**5.5. Algorithm Bias:** AI applications usually work according to the training they received on previous data. The problem arises when insufficient data is triggered, and AI has applied accordingly, so they need to train on unbiased data and produce easy-to-interpret algorithms.

**5.6. Data scarcity:** Although companies and organizations have a huge amount of data, useful data for AI is still insufficient. The most efficient AI is the one that provides supervised training, and this type of training is learned through classified data, which is also inherently scarce.

## 6. CONCLUSION

The technological revolution that is sweeping the world rapidly, and through its employment of artificial intelligence techniques, has had a significant impact on aquaculture agriculture, as it has become possible to develop and improve insurance operations as well as review vast amounts of data in a short time, and discover various diseases and dangers that threaten aquatic life and treat them as soon as possible and at the lowest costs, and help achieve economic well-being, and through our study we extracted a set of results and recommendations listed below.

**6.1. Results:** It is represented in

Artificial intelligence is an actual image in the future aquaculture industry because it allows for improving and developing production and raising product quality—controlling many risks that threaten this agriculture.

Modern aquaculture based on algorithms, artificial intelligence, the Internet of Things, and cloud computing is necessary to improve production and productivity and ensure and promote global food security.

- Employing artificial intelligence in aquaculture cultivation enables the control of means and equipment, as well as reducing the costs of farming and breeding using technological techniques, and this encourages many farmers and entrepreneurs to invest more in the field of aquaculture of all kinds, whether fish, crustaceans, shellfish, algae... etc □

- The use of artificial intelligence techniques by everyone is an imperative necessity, and the insurance sector, like other sectors that adopt artificial intelligence and its applications, this is to complete the stages of fusion in the world of digitization and the technological world

**6.2. Study recommendations:** In light of the findings, we propose the following recommendations:

Establish a solid infrastructure to support and encourage investment in aquaculture agriculture by developing legal legislation that ensures the control of AI applications and makes them resilient to problems and risks threatening aquaculture.

- Strengthen cooperation and partnership in the technology field with information technology and artificial intelligence companies to improve and develop aquaculture agriculture, enhance insurance mechanisms, and prevent risks that threaten it.
- Considering the legal structure of artificial intelligence applications to resolve various issues and disputes resulting from using artificial intelligence, data, and digital information.
- Train researchers and support research centers specialized in technology in general and artificial intelligence in particular, as well as the optimal investment of accumulated scientific and applied knowledge and experience, updating and using them in decision-making related to agriculture of all kinds.

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