Methods

The methodology in this study is to use the literature review method. In this method, four stages are carried out, namely reviewing, reading the initial article, further articles, and evaluating articles. The Source of Journals is from Research Gate, Directory of Open Access Journals, Elsevier, Springer, and Google Scholar. Keywords used to search for relevant discussion topics include the internet of things, fisheries technology, prototype fisheries.

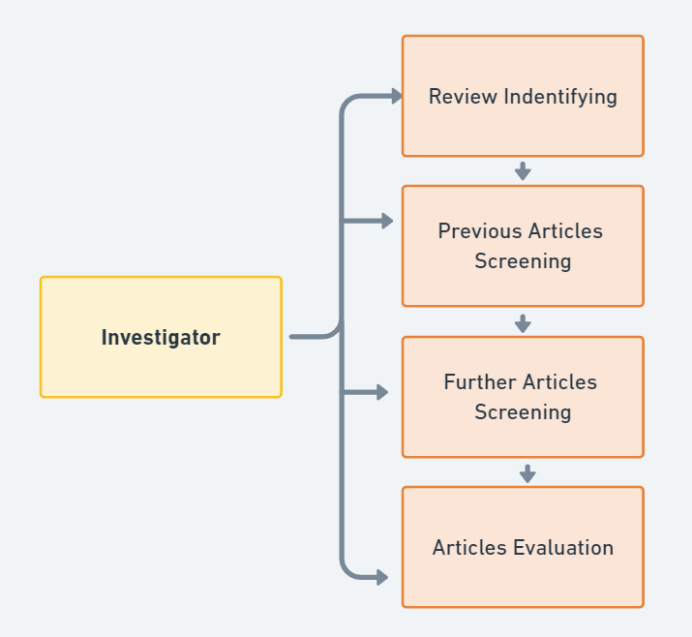

Figure 1. Review Process

This research is to review the importance of the development of IoT technology in aquaculture. Researchers analyse the problems that exist in conducting an iterative review.

Discussion

Based on a simple statistical view, the results of the term "Fisheries IoT" searched the abstract, title, and keywords total of 24, 21 journals and 3 book compositions. Journals are classified in 7 years 2012-2021 as Fig. 2. Graphical of the count of journals:

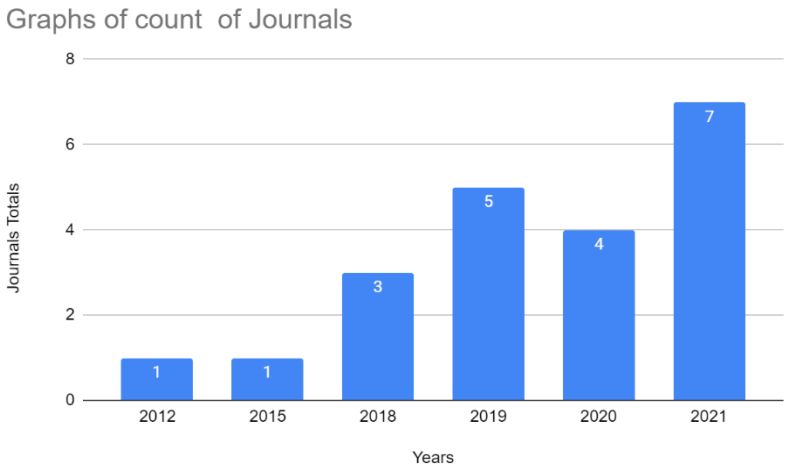

Figure 2. Graphical of the count of journals

The chart explains that there are 5 journals in 2019 and 4 journals in 2020, while the highest number published in 2021 in 8 articles.

Application

Within the reviewed papers it was also identified that the most common applications of IoT solutions for aquaculture management are:

- Water quality monitoring
- Automatic feeder
- Feeding control
- IoT architecture for aquaculture
- Early Prevention System for Sustained Fish and Shrimp Life (APD KID)
- IoT-based fish laureate
- Marketplace

Table 1 presents the reviewed papers, grouping by aquaculture and application of the IoT solution. IoT solutions as Water Quality, Feeding Management. Additionally, "Others" column in Table 2 includes papers whose IoT solutions were developed for other fisheries.

Table 1. Application and IoT Functions for Fisheries

Applications	Totals
Water Quality	8
Feeding Management	4
Others	9

As shown in Table 1, the most application of IoT solutions for aquaculture is water quality monitoring. Other solutions were developed for monitoring Dissolved Oxygen, pH, Water Temperature. The fact function of the application is common in aquaculture can be justified by the relevance that water quality monitoring has for fish farmers.

Water Quality

Water quality is one of the factors in the success of fish farming. Temperature, pH, and oxygen levels in water are examples of indicators to determine water quality [6]. In practice, fish cultivators still measure water quality manually, namely by visiting fish ponds and using simple measuring instruments. It affects the effectiveness of fish farming.

With the development of today's technology, a technological innovation called the Internet of Things has emerged. Internet of Things (IoT) refers to the use of sensors, actuators, and communication technologies embedded into physical objects that allow those objects to be tracked and controlled via networks such as the internet. The use of this device will involve three main steps: data capture using sensors, data collection via a network, and decision-making based on data analysis. This decision-making can result in increased productivity of the current process. It will also enable new types of products and services to be offered in various application areas [7].

By using conventional water quality monitoring methods there are deficiencies such as inaccurate, unable to real-time, and human error, etc. So to overcome these shortcomings we try to make improvements by creating a monitoring system that can be used in real-time. More details can be seen in the table research of water quality monitoring systems with IoT:

Table 2. Research Water Quality Monitoring System with IoT

System or Method	Principle of Procedure	Result	Reference
Raspberry Pi	The equipment needed is an acidity (pH) sensor, a temperature sensor, and a relay to regulate the water oxygen aerator. Data from these sensors is recorded by the Raspberry Pi and then processed into information according to user needs through internet intermediaries automatically. Furthermore, the data can be displayed on various platforms, one of which is the mobile web model.	The development of Internet of Things technology in this system can help farmers to monitor water quality automatically. The developed automation system promises to improve success in catfish farming.	[4]
Microcontroler ESP32	The system works starting from reading	This system can function properly as	[8]

and ADS115	data by the sensor, the data is converted by ADS1115 to be processed by ESP32, then the results are displayed through the Blynk (IoT) application on a smartphone.	evidenced by: (1) data from the sensor is read, (2) the alarm sounds, and the alarm notification is read on the smartphone if the parameter value is outside the specified range.	
Computer vision	This system to measure the growth of goldfish can be implemented using the help of a camera as input for fish images taken directly	The result of extracting the image is in the form of pixel size and using a calculation algorithm, for fish image value converted into cm pixel size with the formula centimeters = pixels * 2.54 / 96 1 in = 2.54 cm for example 3.25 * 2.54 8.255 cm.	[9]
Microcontroler Arduino	The microcontroller is in real-time based on the Internet of Things that integrated with websites and applications on smartphones. A system equipped with an aerator, alkaline liquid pump, heating, and water-cooling system.	monitoring system for temperature, oxygen levels, and water pH has successfully realized with an average data renewal time of every 310 seconds and the control system with the on-off method can maintain the temperature value for giant prawns in the range of 25^0C to 27^0C, pH 7 to 7.5 and oxygen content of 5 mg/L up to 7 mg/L, and resulted in a survival rate of 90% giant prawns with a stocking density of 20 shrimp at 0.32 m^3	[10]
Embedded system	The system is by transferring data from several water quality sensors (Ph, Dissolved Oxygen, Temperature, Turbidity) through an embedded system in a cloud computing system which is then transferred to a web server and android smartphone so that fish farmers can monitor pond water quality using a smartphone. in real-time and integrated with the notification system.	The impact of controlled water quality is to increase the survival rate (SR) of fish by up to 30% so that it can improve the socio-economic status of fish farmers.	[11]
Mikrokontroler ESP32	This system can process voltage data from the pH sensor in real-time, and users can monitor pH and receive notifications when interference occurs wirelessly and in real-time through the application.	At any time the pH is outside the limits of the fish's life capacity, fish farmers will receive an email notification that a disturbance has occurred. As a result, fish farmers can add solutions with a pH value of 7 to adjust the pH so fish can develop optimally.	[12]
cayenne.mydevice.com	Web Internet of thing message queue telemetry transport (MQTT)	The average sensor accuracy is good, 88.86%; there are two obstacles faced, namely sensor maintenance and storage and monitoring the data in living, minute, hour, day, week, month, three months, six months, and a year.	[13]

The importance of water quality monitoring is the management of aquaculture systems. So, it is necessary to continuously monitor and improve technology in order to know the quality of pond water that will be used for fish farmers. Policies related to technology in the aquaculture sector need proof of concept (POC). PoC is also carried out for a policy that is issued as efficiently as possible, and that the policy is well proven and can be carried out on a larger scale. The stages in conducting PoC in technology adoption in the aquaculture sector are: (i) agricultural pre-planning, (ii) program planning, (iii) pre-implementation, (iv) program implementation, and (v) impact evaluation [14].

Feeding Management

The feed factor is the most important factor in supporting the success of cultivation, which is about 60%. Therefore, effective and efficient management is needed. Some of the problems encountered by fish farmers are fish feeding techniques that are

less efficient, namely the unmeasured amount of feed given correctly. If too much feed is given, the remaining feed will become a source of bacteria, increasing the chance of the catfish dying. Currently, most of the feeding is done manually. This of course will be less efficient if the cultivator has many ponds or has a side job, for example managing rice fields or gardens.

Several studies on automatic fish feeding management have been carried out, including research conducted with the design of automatic fish feeders with a scheduling system, or feed control tools as the following table describes research related to feeding management using the IoT system.

Table 3. Research of IoT Application for Feeding Management

Utility	Tools or System	Result	Reference
Controlling catfish feeding remotely	Using a microcontroller, internet shield, motor servo, and motor DC.	The result is devices for catfish feeding and website that can be used for controlling catfish feeding remotely. The device integrated with the website can determine the amount of feed or schedule for catfish feeding. Its testing has shown that catfish feeding with IoT is increases efficiency in the amount of feed and schedule for catfish feeding.	[15]
Auto feeder	Modul Node MCU integrated with the wi-fi module is used as a microcontroller. The monitoring system is built using the Firebase real-time database. The remaining feed in the container can be detected by ultrasonic sensors.	The accuracy rate of the system was 96.8%. QoS testing, such as delay, throughput, packet loss, and jitter on the monitoring system for communication on yields a very good value and indexed four based on the TIPHON standard.	[16]
Auto Feeder	This automatic feeder system works automatically and is controlled via an application on a Smartphone. Sensors in the system work to get data then processed by the microcontroller and sent to the server.	The design made has an ejection range of approximately 3 meters. IoT monitoring of pool conditions in the form of temperature and pH has worked and can monitor in real-time on a smartphone.	[17]

Along with technological developments, IoT is indeed widely used in feeding feed or feed management in aquaculture. Therefore, there is a need for a design related to the automatic feeding system in aquaculture using an IoT application. Fish Farmers can control feeding from anywhere and anytime only monitor the remaining fish feed in the container and control the management of feeding for using this system.

In feeding, the thing that must be considered is the weight of the feed released and the regulated feeding schedule. In the nursery phase, the right time for feeding is in the morning, afternoon, and evening. To help and make it easier for fish keepers and cultivators, a tool that can work automatically provides feed.

Based on Harifuzzumar's research (2018) [18] that automatic fish feeding tools usually use Arduino mega2560 as the main controller for all components, servo motor as an open and close driving motor for fish feed output, ultrasonic sensor to measure fish feed level in storage containers, esp8266 module as a tool. For communication between Arduino and Android smartphones through internet network media and the Blynk application as a feed level display interface and feed output control on android smartphones.

Another research [19] auto-feeder consists of pellet storage, former, stand, DC motor, and microcontroller. The pellets are controlled by a DC motor located under the pellet storage. A control system was then attached to this device to allow the fish to be fed at the right cycle time as required or predefined by the user. The timer was employed in this device to control the motor rotation attached to the sphere former, which dispenses the pellets into the water. Pellets are dispensing into the marking area of the pond based solely on the rotation speed of the motor itself. The controller came with a keypad giving users more options in determining the suitable speed for the motor depending on their cattle. In short, the pellets in the automatic fish feeder system will be controlled by the rotation speed of the DC motor.

The Other Uses

Another use in aquaculture management carried out by Tarnadi et al (2015) [5] is an application of Fish and Shrimp Early Prevention Tool (APD KID) technology, to determine the performance and effect of PPE KID in reducing fish and shrimp mortality. APD KID output is equipped with a heater integrated with zeolite and charcoal. Effect of PPE KID can reduce mortality

in fish, carp in larvae. So that when testing the effect of PPE KID on 10,000 carp fry, as many as 5,000 carp with PPE KID live 98% while as many as 5,000 carp without PPE KID die due to extreme temperature changes. Thus the presence of PPE KID can optimize fish production by 98%.

Another innovation of IoT solutions based on research by Rahman (2019) [20] is Fishio. The application facilitates marketing and helps fish farmers and consumers order and find their needs. To make it easier for fisheries farmers to market their products so far and make it easier for consumers to order pond fisheries products. The development of this application uses prototyping as a software development method because the application will address many users in the future, iterations can be carried out in its development. By using the Android platform and Firebase as a service provider, expected to solve the existing problems. This application gets a score of 67.5 on a scale of 100 for seller applications and a score of 75 on a scale of 100 for buyer applications.

So the fisheries sector has the potential to be developed. With good management, this sector can contribute to national food security and improve welfare for the people. With the development of the internet of things (IoT) technology today, this technology can provide solutions for fish farmers to overcome these obstacles. According to research Sudianto (2019) [21] proposes IoT architecture for gourami cultivation. IoT architecture in this study has six designs there are domain model, business process hierarchy, IoT layer, deployment, information, and interoperability endpoints. The IoT architecture is expected to build the IoT system to the needs of gourami farmers and make it easier for developers to build and develop the system.

Then, another IoT solution for intelligent pond monitoring is designed with affordable and open-source electrical components to provide a cost-efficient solution for farmers. Five sensors were used to measure each parameter. A web application prototype is also presented as a companion application for the users to get helpful information from the IoT device. It was developed using a Python framework. By accessing this web application, the users can immediately detect any abnormal conditions of the pond [22]

Along with the rapid use of the Internet of Things, an automated aquaculture system utilizing this technology can increase the productivity of fishery products. Aquaculture is the main sector that determines the number of fishery products. The application of Smart Aquaculture is needed in aquaculture [23] because smart farming is a farm management concept that may use the Internet of Things (IoT) and applications of artificial intelligence (AI) technologies for improving the sustainability of the smart fishery have become widespread [24] [25]

Conclusion

This study highlights the fact that there are IoT solutions for aquaculture management. Within the reviewed papers the most common applications of IoT solutions for aquaculture management are Water quality monitoring, automatic feeder, feeding control, IoT architecture for aquaculture, Early Prevention System for Sustained Fish and Shrimp Life (APD KID), IoT-based fish laureate, and marketplace.

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