Developing and application to the fishing industry with the internet of thing (IoT)

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Received: March 2022 Accepted: June 2022

Abstract

Advances in technology affect all sectors to a greater or lesser extent. Technology affects all sectors, from agriculture to education, from health to entertainment. These developments also concern the field of fishing in recent years. In some aspects of fishing, technology offers advantages to fisheries with its innovations. As in all sectors, the relationship between fisheries management and technology has shown an inseparable integrity in recent years. The collection of data on fisheries, the analysis of this data, and the correct management of the data provide many conveniences to this field. Fisheries data is an important part of fisheries management. The problems experienced in the data bring with it different problems. In this study, an application with the Internet of Things (IoT) was designed to be used in fisheries management. Thanks to this application, the pH and temperature ratios of the environments where the fish are grown are determined. In addition, the transfer of the obtained data over GSM is also transmitted to the manufacturers at certain periods. As a result of the study, it has been determined that the designed application and the obtained findings benefit the manufacturers and the system works smoothly.

Keywords: Internet of Things, Fisheries, Fisheries Management, Management Information Systems

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[DOI: 10.18331/SFS2022.9.1.9]

Introduction

Recent advances in current technology are advancing fisheries data systems. It provides a series of solutions for updating, modernizing, data collection and analysis of these systems. Otherwise, the scarcity of data on fisheries causes uncertainty about the stock. Stock uncertainty puts consumers' food safety at risk. In this sense, it is necessary to collect and best manage data on fisheries (Bradley and *et al*., 2018).

It is necessary to implement management systems and determine management strategies for effective fisheries. Management strategy evaluation is effective in solving many problems. In this sense, fisheries management is important in stock assessment, determination of research priorities, implementation and decision making. It requires collaboration in industry, science and other fields (Smith *et al*., 1999). It is seen that there are strange atmospheric environments such as hot and cold, environmental problems in which fish can survive, different problems in fishing, and these problems have been tried to be solved with technologies and methodologies for many years (Link, 2002).

Today, technology is used to solve problems in the field of fisheries, as in different fields. We see that topics such as artificial intelligence, data analysis, geographic information systems, machine learning and system analysis, which are popular topics in the field of technology, are used in fishing (Link, 2002; Meaden, 2009; Alagappan and Kumaran, 2013; Bradley and *et al*., 2018; Kale and Acarli, 2018; Ahmad, 2019). In the studies conducted with the officials of the enterprises on fisheries, it has been determined that there are problems arising from the failure of the technical infrastructure to be fully provided, as well as the enterprises that operate with technology in accordance with certain standards (Bilgin-Topçu, 2012).

Internet of Things (IoT), one of the current issues of information systems, is used in health, education, security, industry and many other areas (Aktaş *et al*., 2016; Ercan and Kutay, 2016; Altınpulluk, 2018; Uludağ and Uçar, 2018; Baz and Uludag, 2021). The Internet of Things is expressed as the communication of all kinds of objects with other objects through the internet (Bıçakçı, 2019). The Internet of Things is the whole system formed by connecting objects to the Internet environment. It must meet the criteria of reliability, heterogeneity, scalability, interoperability, and security/privacy on the basis of IoT (Çavdar and Öztürk, 2018) (Fig. 1).

In studies with the Internet of Things (IoT), sensors and codes are needed for the system to work correctly. A system built with the internet of things (IoT) can collect, process and send data. In this way, decisions on business-related issues, especially businesses, can be taken and analyzed quickly. As a result, gains are obtained in terms of time and economy.

[DOI: 10.18331/SFS2022.9.1.9]

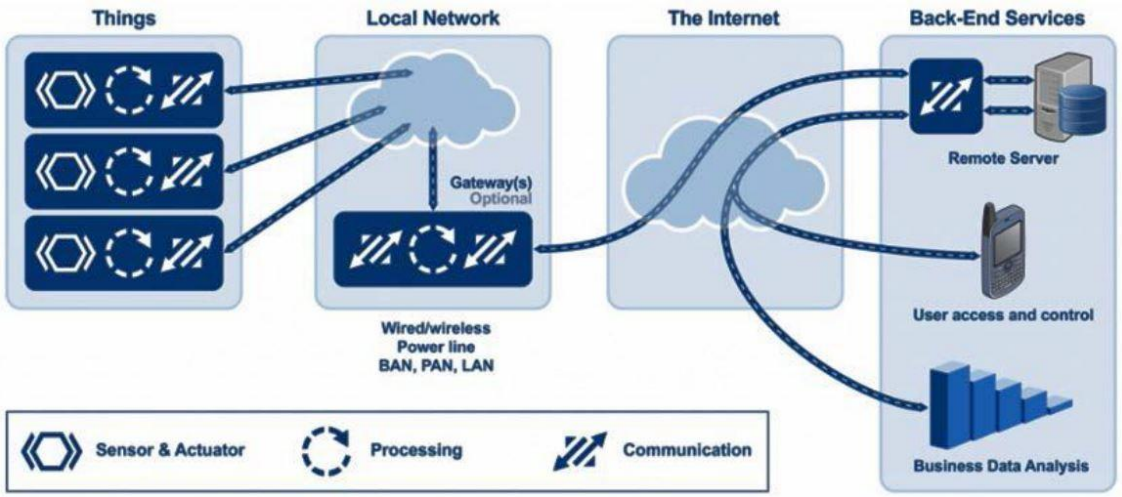

Figure 1: An IoT System Overview (Başçiftçi and Gündüz, 2019).

Despite the prevalence of consumer technology, the integration of technologically advanced data systems into fisheries management remains the exception rather than the rule (Bradley and *et al*., 2018). With this study, it is ensured that the data in the field of fisheries management is collected correctly and instantly delivered to the producers via GSM. This study is important in terms of fisheries management.

The collection of data related to fisheries, the analysis of this collected data, and the correct management of the data provide many conveniences to the field. Fisheries data is an important part of fisheries management. In this study, an application with the Internet of Things (IoT) was designed to be used in fisheries management. Thanks to the designed application, the pH and temperature ratios of the environments where the fish are grown are determined. In addition, the transfer of the obtained data over GSM is also transmitted to the manufacturers at certain periods.

Materials and methods

In this study, an exemplary system design was made with some hardware and software components in order to present basic information to researchers and to monitor the benefits of information technologies in the fishing industry by examining the findings obtained in the light of different studies on the Internet of Things (IoT). In the software part of the study, Python software language, C++ language, nginx web server and modules, mysql database and python libraries, SNMP components, Linux Operating System cron task manager; On the hardware side, using Arduino Nano Clone V3, Raspberry Pi 4 Model B, DS18B20 waterproof digital temperature sensor, Analog pH Sensor, the data obtained from the sensors are processed within the scope of IoT technologies and transferred to a central server. The data collected on the central server were converted into graphics in a web interface developed using internet technologies and visualized and allowed the breeders to monitor.

[DOI: 10.18331/SFS2022.9.1.9]

In the study, a model and an example application of the Internet of Things (IoT) concept in the field of fish farming, where the growers can monitor the temperature and pH values of the ambient water, are emphasized.

The study was carried out in the city of Adana in Turkey, on January 23, 2022, in the sea at the coordinates 36,7822785-35,8148574, in a fishery farm where fish production is carried out. The hardware units used in the study are placed in a box. Temperature and pH sensors were left outside the box and contacted with water. In this way, it has been tried to obtain accurate data without the hardware units being affected by water. Before the study, the system was tested for a certain period of time and the accuracy of the data was checked. The collected data was obtained safely and the analysis study was carried out.

System design

In this section, the design of the sample system prepared, Raspberry Pi 4 Model B, Arduino Nano Clone V3, sensors, processing and sending the sensor data to the central server, software and coding are included (Fig. 2).

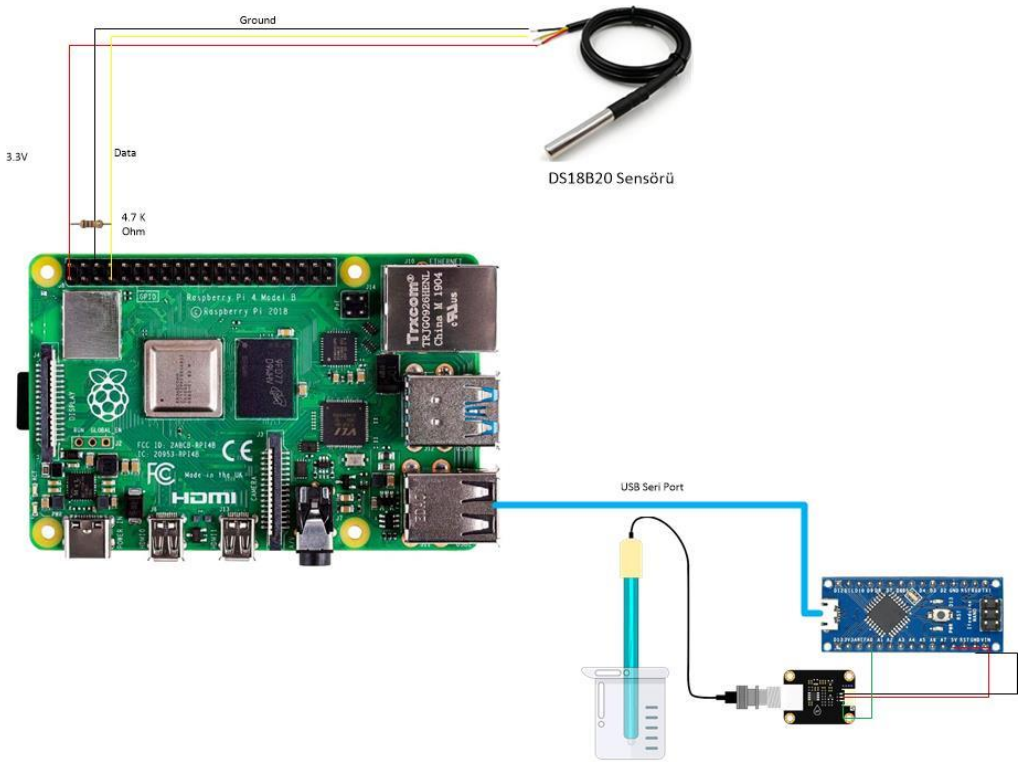

Figure 2: Example drawing image showing the hardware components of the system.

Raspberry Pi 4 Model B

Raspberry Pi is a palm sized development board with 4 USB ports, one ethernet port, wireless network (wi-fi), 1 HDMI port, SD card slot and 40 Gpio pins (Varghese *et al.*, 2019).

The Pi 4 Model B used in the study is a device that was released in June 2019, offering 1.5 GHz 64-bit quad-core ARM

[DOI: 10.18331/SFS2022.9.1.9]

Cortex-A72 processor, built-in 802.11ac Wi-Fi, bluetooth, gigabit ethernet, 2 GB RAM and resolution up to 4K. it has dual micro HDMI ports (Raspberry_Pi, 2022).

It can work with Microsoft Windows IoT or Linux-based Raspbian OS developed for it. The Rasbian OS operating system was used in this research. The reasons for choosing this card in the study can be listed as sharing information in the discussion forums on the manufacturer's licensed site, easily adding sensors, not needing any additional hardware for web, database and other applications, and its integrated structure.

Arduino nano klon V3

It is a smaller ATmega328 or ATmega168 microprocessor based development board compared to Raspberry Pi. It can work with a Mini USB cable without the need for an external adapter (ArduinoBoardNano, 2022). In the study, it was used to digitize the analog data coming from the pH sensor and transfer it to Raspberry Pi 4 from the USB port.

Sensors

DS18B20 is a digital temperature sensor that supports single-cable protocol, can measure temperature from -55℃ to +125℃ with +-5% accuracy. Data from a single wire is 9 to 12 bits long. It can be controlled with a single microcontroller pin as it supports single-cable protocol. It does not need any additional power as it can be powered from the data line. It can work with 3.0V or 5.5V, which it receives through the microcontroller (Runjing *et al.*, 2011). In the study, the temperature of the water in the aquaculture ponds is measured with the help of this sensor, which is connected to the gpio pins on the Raspberry Pi, and the data obtained as a result of the measurement is sent to the central server.

Analog pH sensor is a sensor specially designed to reflect the acid or alkaline value of the liquid by measuring the pH value of the solution. This sensor is used in applications such as aquaponics, aquaculture, medical research, agricultural research and environmental water testing. It can operate between 3.3V~5.0V with the built-in voltage regulator chip. The pH value is usually between 0 and 14; if the value measured by the sensor is 7, the solution is neutral; less than 7 acidic; If it is greater than 7, it is detected as alkaline (Analog pH Sensor/Meter Kit V2, 2022). In the study, the analog data coming from the sensor is digitized via Arduino Nano Clone V3 and sent to the Raspberry Pi development board using the USB serial port, and then sent to the central server.

Raspberry Pi OS

Raspberry Pi OS is a free Debian-based operating system optimized and recommended for the Raspberry Pi development board. The operating system comes with more than 35,000 packages. It includes precompiled packages for easy installation (Raspberry Pi OS, 2022). The first

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optimized structure of the aforementioned 35,000 packages was completed in June 2012. However, these Debian packages, which are still used with an emphasis on development, are constantly being improved. This operating system, which is highly optimized for ARM-based processors, has versions such as stretch, jessie and buster. In the standard installation of the desktop version, it comes with components such as mathemetica and chromium web browser (Balon and Simić, 2019).

Digitizing the pH sensor with Arduino Nano Clone V3

The circuit board with the analog pH Sensor used in the study and a BNC connector on which the probe will be connected and a potentiometer for sensitivity adjustment was connected to the Arduino Nano Clone V3 as shown in Figure 3. Thanks to the software developed for Arduino Nano Clone V3, the data received from the connected sensor is sent to the USB port of the Raspberry Pi development board via the USB serial port.

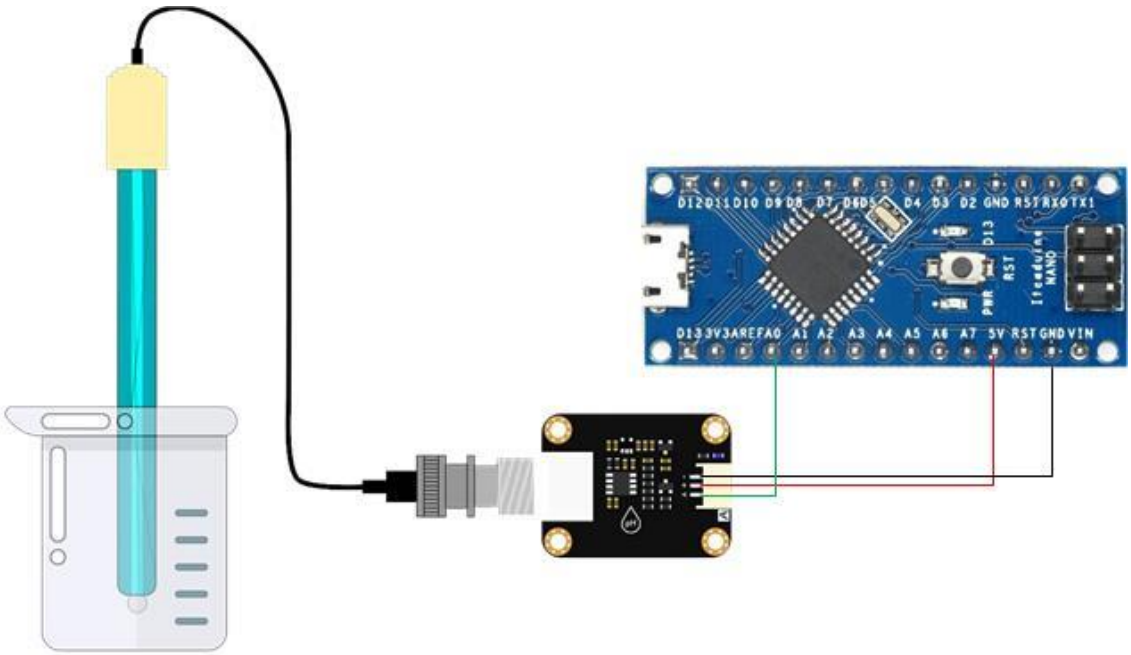

Figure 3: Arduino Nano Clone V3 Connection with pH Sensor.

Software and coding

In this research, Debian-based Raspberry Pi OS was installed on the Raspberry Pi development board, which is the main component of the system. The Python programming language was used for the scripts used to receive data from the sensors and to operate using the received data. MySQL database and Python libraries to record data both on the device and on the remote server; Python W1ThermSensor and Serial libraries were used to get ambient values from heat and pH sensors. Linux task scheduler (cron) is used to send the data to the remote server at the specified time interval. In order to read the data from the database and monitor it from a web

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interface on the remote server, a web-based software has been developed by using the PHP language and Google chart components on the remote server. All sample codes of the system are shown below.

Arduino Nano Clone V3 pH meter codes

The Arduino Nano Clone V3 pH Meter Codes used in the study are given in Figure 4.

```
/*
# pH Metre Örnek Kodları
 # Editor : kuludag
 # Date   : 17.01.2022
 # Ver    : 0.1
 # Product: pH metre
 # SKU    : Gravity pH Sensor
*/

#define SensorPin 0          //pH metrenin Analog çıkışından Arduino Nano Analog giriş 0 a gönder
unsigned long int avgValue;  //Sensör ölçümünün ortalama değerini sakla
float b;
int buf[10],temp;

void setup()
{
  pinMode(13,OUTPUT);
  Serial.begin(9600);
}
void loop()
{
  for(int k=0;k<10;k++)       //Değerleri optimize etmek için sensörden 10 adet örneklem al
  {
    buf[k]=analogRead(SensorPin);
    delay(10);
  }
  for(int k=0;k<9;k++)        //Alınan değerleri küçükten büyüğe sırala
  {
    for(int m=k+1;m<10;m++)
    {
      if(buf[k]>buf[m])
      {
        temp=buf[k];
        buf[k]=buf[m];
        buf[m]=temp;
      }
    }
  }
  avgValue=0;
  for(int k=2;k<8;k++)                      //örneklem merkezinden 6 örneğin aritmetik ortalamasını al
    avgValue+=buf[k];
  float phValue=(float)avgValue*5.0/1024/6; //analog veriyi milivolt a dönüştür
  phValue=3.5*phValue;                      //milivolt veriyi pH verisine dönüştür ve ekrana yazdır
  Serial.print(phValue,2);
  Serial.println(" ");
  digitalWrite(13, HIGH);
  delay(800);
  digitalWrite(13, LOW);

}
```

Figure 4: All sample codes of the system.

Python codes processing data from temperature and pH sensors

Python codes used in processing data from heat and pH sensors in the study are shown in Figure 5.

Example of scheduled task code sending findings to local device and remote server

Below is an example of scheduled task code that sends research findings to local device and remote server (Fig. 6).

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```
import sys
import time
import serial
import mysql.connector
from w1thermsensor import W1ThermSensor

isisensor = W1ThermSensor()
if __name__ == '__main__':
    ser = serial.Serial('/dev/ttyUSB0', 9600, timeout=5)
    ser.reset_input_buffer()
while True:
    isiham = isisensor.get_temperature()
    isi = ("%0.1f" % isiham)
    print(isi)
    dbbaglanserver = mysql.connector.connect(user="user", password="password",
host="192.168.1.20", port=3306, database="SENSORDATA")
    dbbaglanlokal = mysql.connector.connect(user="user", password="password",
host="localhost", port=3306, database="SENSORDATA")
    curserver = dbbaglanserver.cursor()
    curlokal = dbbaglanlokal.cursor()
    sqlisi = "INSERT INTO TEMPERATURE(TEMPERATURE) VALUES(%s)"
    deger = (isi,)
    curserver.execute(sqlisi, deger)
    curlokal.execute(sqlisi, deger)
    dbbaglanserver.commit()
    dbbaglanlokal.commit()
    time.sleep(2)

    if ser.in_waiting > 0:

        satir = ser.readline().decode('utf-8').rstrip()
        print(satir)
        sqlph = "INSERT INTO PH(PH) VALUES(%s)"
        deger = (satir,)
        curserver.execute(sqlph, deger)
        curlokal.execute(sqlph, deger)
        dbbaglanserver.commit()
        dbbaglanlokal.commit()
        ser.close
        dbbaglanserver.close()
        dbbaglanlokal.close()
        sys.exit(1)
```

Figure 5: Python Codes Processing Data from Temperature and pH Sensors.

Software code example showing findings graphically in web based software

The software code that graphically displays the findings of the research in web-based software is shown in Figure 7.

Screenshot of web based software showing findings in graphical form

The screenshot of the web-based software showing the findings of the research in graphic form is shown in Figure 8.

Results

In this study, the pH and temperature ratios of the environments where the fish are grown were determined thanks to the application designed with the Internet of Things to be used in fisheries management. In addition, the transmission of the obtained data via GSM was also communicated to the manufacturers at certain periods.

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```
# Each task to run has to be defined through a single line
# indicating with different fields when the task will be run
# and what command to run for the task
#
# To define the time you can provide concrete values for
# minute (m), hour (h), day of month (dom), month (mon),
# and day of week (dow) or use '*' in these fields (for 'any').
#
# Notice that tasks will be started based on the cron's system
# daemon's notion of time and timezones.
#
# Output of the crontab jobs (including errors) is sent through
# email to the user the crontab file belongs to (unless redirected).
#
# For example, you can run a backup of all your user accounts
# at 5 a.m every week with:
# 0 5 * * 1 tar -zcf /var/backups/home.tgz /home/
#
# For more information see the manual pages of crontab(5) and cron(8)
#
# m h  dom mon dow   command
0 * * * * python /home/pi/sensors.py
```

Figure 6: Scheduled Task Code Sending Findings to Local Device and Remote Server.

```
<script type="text/javascript">
 google.load("visualization", "1", {packages:["corechart"]});
 google.setOnLoadCallback(drawChart);
 function drawChart() {
 var data_valtemp = google.visualization.arrayToDataTable([['Tarih','Sicaklık'],
<?php
 $sqlisi = $db->query("SELECT * FROM TEMPERATURE", PDO::FETCH_ASSOC);
 foreach($sqlisi as $satirisi){
 echo "['".$satirisi['DATETIME']."',".$satirisi['TEMPERATURE']."],";}
?>
 ]);
 var data_valph = google.visualization.arrayToDataTable([
['Tarih', 'PH Değeri'],
<?php
$sqlph = $db->query("SELECT * FROM PH", PDO::FETCH_ASSOC);
foreach($sqlph as $satirph){
echo "['".$satirph['DATETIME']."',".$satirph['PH']."],";
}
?>
]);
var options_valisi = {
 title: 'Sıcaklık Sensörü',
 colors: ['red', 'green'],
 width: 1200,
 height: 400,
 bar: {
 groupWidth: 5
}
 };
 var options_valph = {
 title: 'PH Sensörü',
 colors: ['green', 'red'],
 width: 1200,
 height: 400,
 bar: {
 groupWidth: 5
}
 };
 var chart_valisi = new
google.visualization.ColumnChart(document.getElementById("columncharttemp"));
 chart_valisi.draw(data_valisi, options_valisi);
 var chart_valph = new
google.visualization.ColumnChart(document.getElementById("columnchartph"));
 chart_valph.draw(data_valph, options_valph);
 }
 </script>
```

Figure 7: Software Code Displaying Findings Graphically in Web Based Software.

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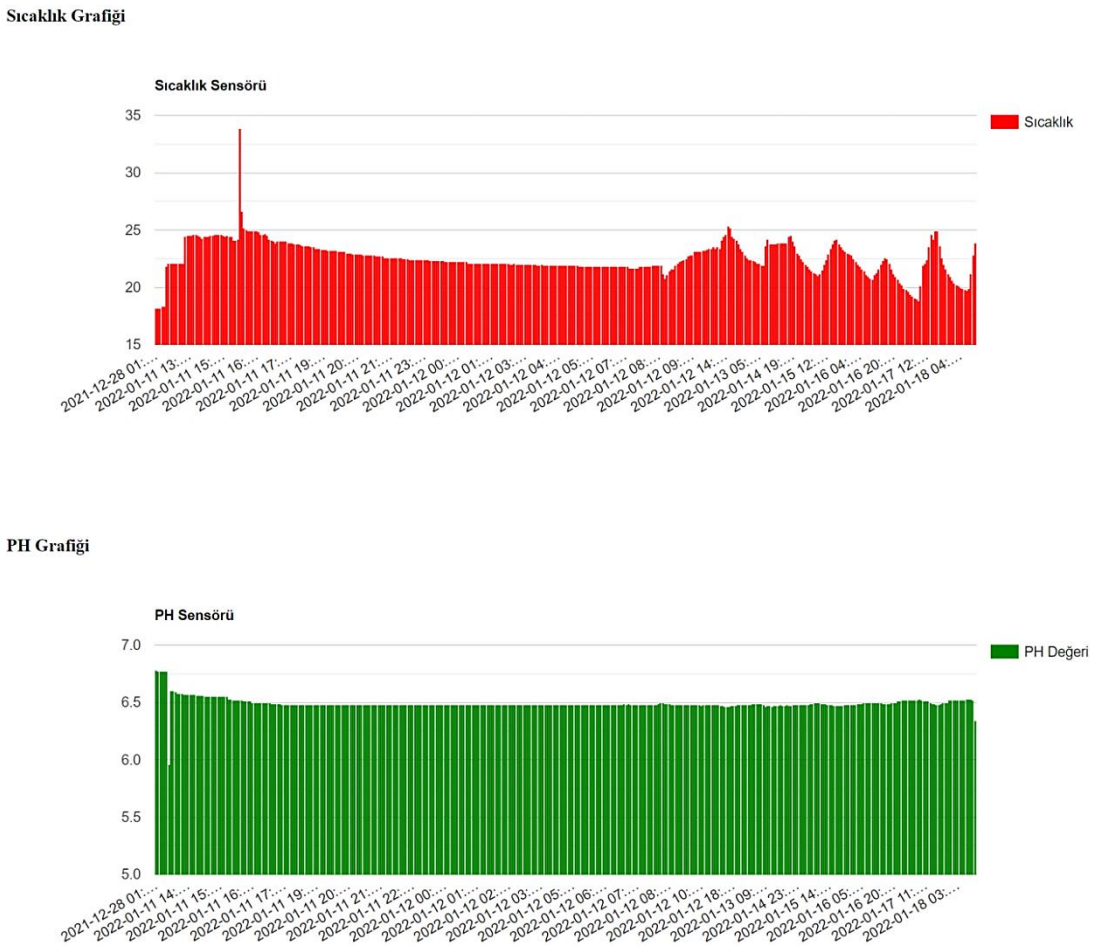

Figure 8: Screenshot of Web Based Software Showing Findings in Graphical Form.

The developed sample application was tested in the sea fishing waters located at the geographical coordinates of 36,7822785, 35,8148574 on the coast of Yumurtalık District of Adana Province.

As a result of the measurements that took about 2 hours, the temperature graph and pH graph of the water were obtained. The results of the findings obtained as a result of the measurements are shown in Figure 9.

In the study, the temperature graph and the pH graph are given in Figure 9. The findings are given according to the actual measurement results from sea water.

As a result of the findings obtained, the average temperature value of the sea water measured on January 23, 2022 is 14.73 degrees celsius; It was observed that the pH value was 7.25. From this point of view, it has been seen that the water temperature has suitable conditions for larval and adult breeding according to the quality criteria of the Ministry of Agriculture and Forestry (TarımOrman, 2022) in this region, where sea bream and sea bass fish are grown.

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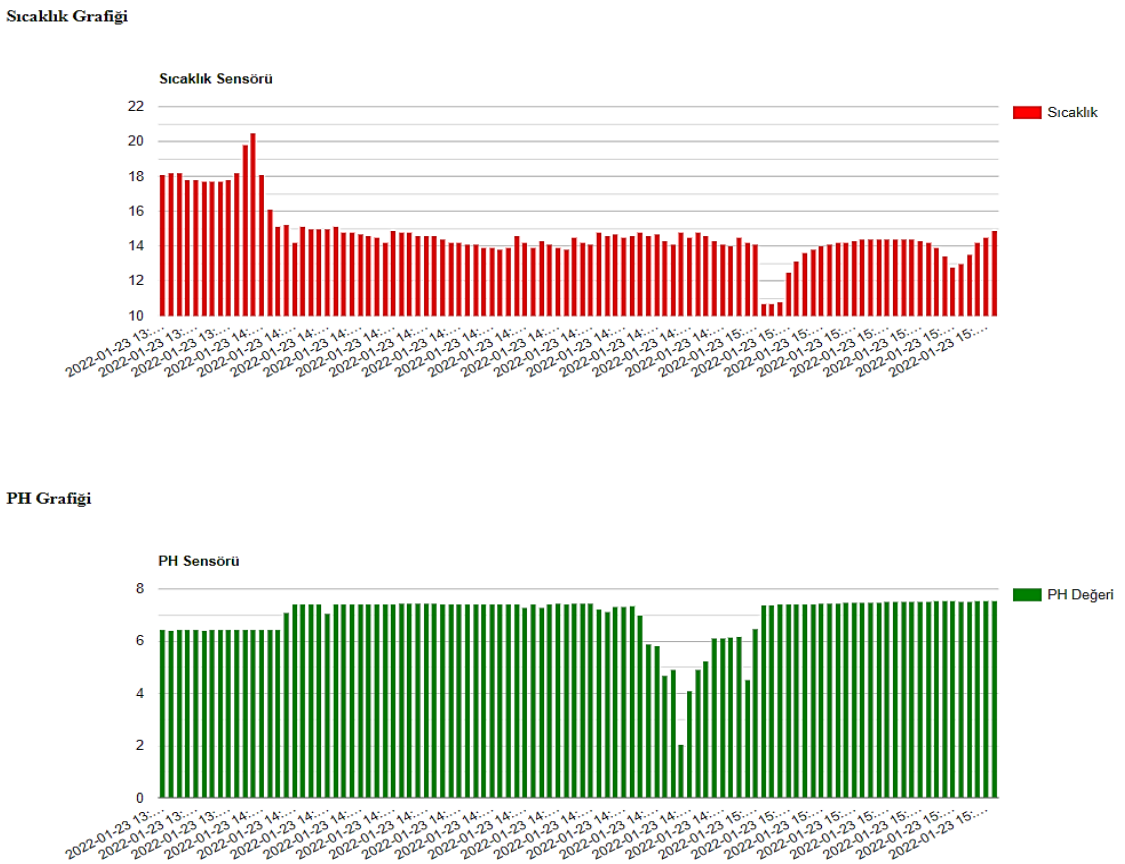

Figure 9: Sea Water Actual Measurement Results.

Discussion

The relationship between fisheries management and technology has shown an inseparable integrity in recent years. The collection of data on fisheries, the analysis of this data, and the correct management of the data provide many conveniences to this field. Fisheries data is an important part of fisheries management. The problems experienced in the data bring with it different problems.

In this study, an application with the Internet of Things (IoT) was designed to be used in fisheries management. Thanks to this application, the pH and temperature ratios of the environments where the fish are grown were determined. In addition, the transfer of the obtained data over GSM is also transmitted to the manufacturers at certain periods. As a result of the study, it has been determined that the designed application and the obtained findings benefit the manufacturers and the system works smoothly.

As a result of the findings obtained, the average temperature value of the sea water measured according to the measurement results is 14.73 degrees Celsius; It was observed that the pH value was 7.25. In this sense, according to the quality criteria of the Ministry of Agriculture and Forestry, in the region where sea bream and sea bass fish are grown, it has been observed that the water temperature has suitable conditions for larval and adult breeding.

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It is necessary to implement management systems and determine management strategies for effective fisheries. Management strategy evaluation is effective in solving many problems. It is seen that there are atmospheric environments such as hot and cold, environmental problems in which fish can survive, different problems in fishing, and these problems have been tried to be solved with technologies and methodologies for many years. In this sense, it is anticipated that the study will contribute to the literature.

Suggestions for future studies in this area;

- It may be suggested that researchers work with different sensors in future studies, such as a salinity sensor.
- It can be suggested that researchers work in different environments, in different seasons in future studies and compare the findings they will obtain with other studies.
- Contrary to this study, in future studies, it can be suggested that fish living in fresh water should work in their environment.
- It may be recommended to collect longer-term data in different time periods in new studies to be done.

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[DOI: 10.18331/SFS2022.9.1.9]