

Web Based Data Logging System Design For Controlled Environments

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Abstract—The increasing global population and the limited availability of arable land necessitate improvements in agricultural production methods. Controlled environment agriculture (CEA) has become increasingly important, as it enables researchers to perform precise experiments when outdoor conditions are inadequate. In agricultural laboratories, regulating indoor environments often requires high-cost equipment, and the continuous operation of these systems is essential to obtain reliable results. Any interruption or malfunction in climate control mechanisms can cause inaccurate measurements, leading to financial and labor losses. Therefore, there is a growing demand for an affordable system capable of remote supervision and consistent data recording. While several commercial solutions are available to perform such tasks, their adoption remains limited due to high purchase costs and dependence on proprietary manufacturer infrastructures. Developments in electronics, particularly in microcontroller and sensor technologies, now make it possible to design low-cost alternatives. Among these, Arduino boards stand out for their open-source design, flexibility, and broad sensor compatibility. In this study, an Arduino UNO microcontroller was combined with a DHT11 temperature–humidity sensor and an Ethernet shield to create a web-based data logging system. The collected data were transmitted via PHP to a MySQL database and stored at ten-minute intervals. The system was implemented in the Crop Stress Monitoring and Thermography Laboratory at Çanakkale Onsekiz Mart University, operating reliably. With an overall cost of about 50 USD, it provides a scalable, adaptable, and efficient solution for environmental monitoring in controlled agricultural research.

Keywords: *Arduino, Ethernet shield, Temperature-humidity sensor, Web database, MySQL*

I. INTRODUCTION

The global population continues to grow, while arable land remains limited, making the intensification of agricultural production increasingly necessary [1]. Although many agricultural studies are conducted

under field conditions, controlled environment research has become vital, especially for experiments that demand precise regulation of environmental factors. In some cases, such studies can only take place in laboratory settings [2]. These laboratories often depend on expensive equipment to maintain and monitor conditions, and ensuring uninterrupted operation is crucial for producing reliable and reproducible results. Any malfunction—particularly within climate control systems—can threaten long-term experiments, potentially resulting in financial costs and additional labor. Consequently, there is a growing need for affordable systems that support remote supervision and continuous data logging [3].

In recent decades, sensor-based technologies have advanced significantly within agriculture and controlled environments. Many studies have explored greenhouse monitoring and environmental control systems to enhance crop stability and overall productivity [4, 5]. Alongside this, wireless sensor networks (WSNs) and Internet of Things (IoT) architectures have expanded, offering real-time insights into temperature, humidity, and soil conditions, which enable data-driven decision-making in agricultural management [6-8]. These developments highlight the importance of reliable, scalable data collection infrastructures in modern agricultural research [9].

Open-source microcontroller platforms, particularly Arduino-based systems, have emerged as practical and cost-efficient alternatives to proprietary solutions. Their affordability, adaptability, and wide sensor compatibility make them ideal for research environments where budget constraints often limit access to commercial equipment [10-12]. Prior studies have shown that these platforms can be integrated effectively into environmental monitoring frameworks, enhancing both sustainability and long-term operational efficiency [13, 14].

Building on these advances, this study presents a modular, web-based data logging system designed for agricultural laboratories. The setup combines an Arduino UNO microcontroller with a DHT11 temperature–humidity sensor and an Ethernet shield to transmit data to a PHP–MySQL database every ten

minutes. The system was successfully deployed in the Crop Stress Monitoring and Thermography Laboratory at Çanakkale Onsekiz Mart University, operating reliably and without interruption. At a total cost of approximately 50 USD, this design offers an affordable, scalable, and sustainable solution for environmental monitoring, contributing to ongoing improvements in controlled agricultural research.

II. MATERIALS AND METHODS

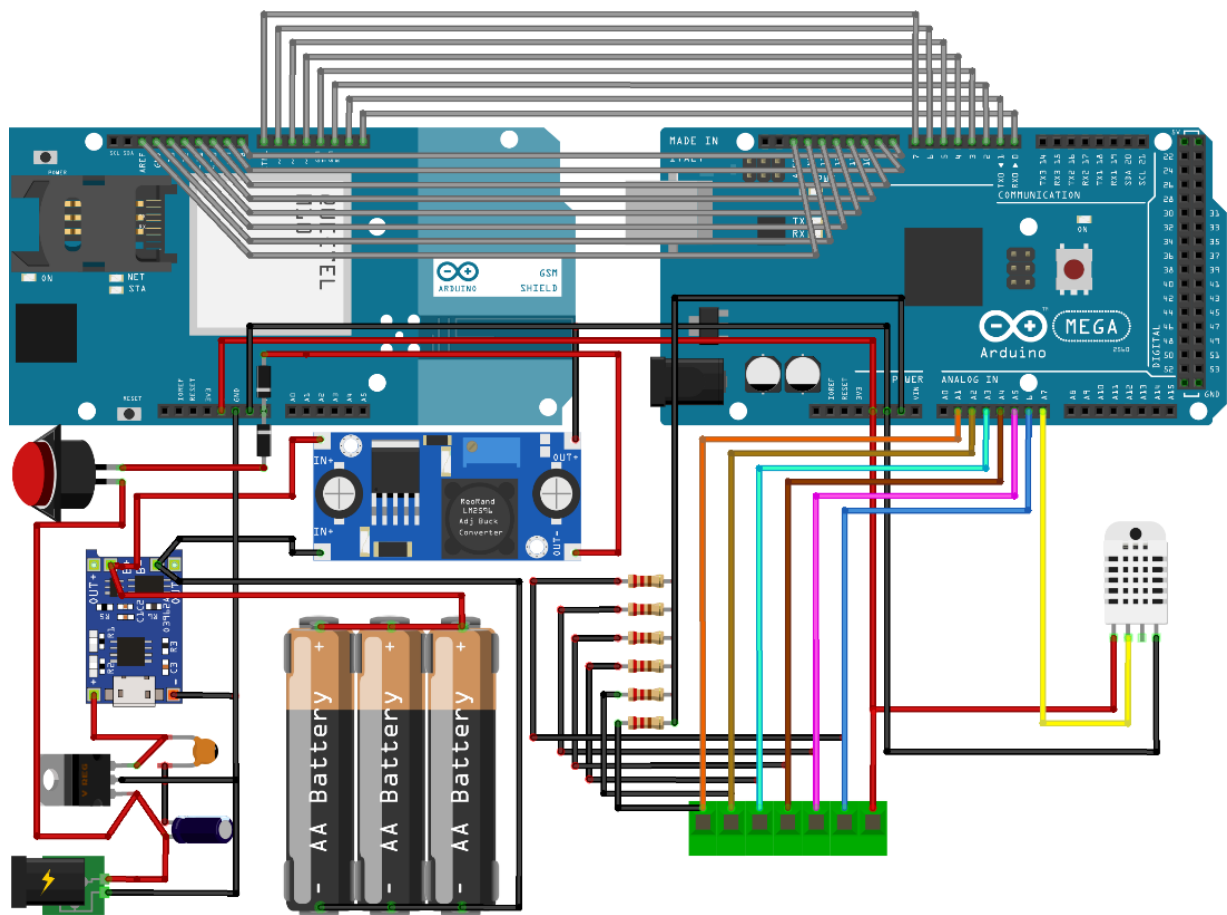
A. System Design

The developed system was created to enable continuous observation and recording of environmental parameters within controlled agricultural settings. Its architecture is composed of three primary components: (i) hardware elements responsible for collecting and transmitting data, (ii) software tasked with data processing and communication, and (iii) a web-based database that stores and allows retrieval of

B. Hardware Components

The hardware module was assembled using affordable and readily accessible components. At its core, an Arduino UNO (R3) microcontroller handled all processing tasks, chosen for its open-source design, programming simplicity, and compatibility with a range of peripheral devices. Environmental conditions were recorded using a DHT11 digital temperature and humidity sensor, which delivers pre-calibrated digital output signals. The collected data were then transmitted through an Arduino Ethernet Shield, leveraging built-in TCP/UDP communication protocols.

The system's hardware configuration is illustrated in Figure 1, created using Fritzing software. This schematic shows the connection between the DHT11 sensor, the Ethernet shield, and the Arduino UNO microcontroller. The simplicity of the circuit design ensures easy replication and potential scalability



environmental information.

through the addition of further sensors.

Figure 1. Hardware schematic of the proposed system (Fritzing design).

C. Software Development

A custom software program was developed and uploaded to the Arduino board using the Arduino IDE. The program was responsible for sensor initialization, data acquisition, and transmission of sensor values to the server at predefined intervals. Data were collected

every 10 minutes and transmitted in single-row format to minimize communication overhead.

On the server side, a PHP-based script was implemented to receive and process incoming data packets. These values were then transferred to the database, ensuring synchronization between the

hardware unit and the storage system. Software has shown in Figure 2, developed for both microcontroller

board and database.

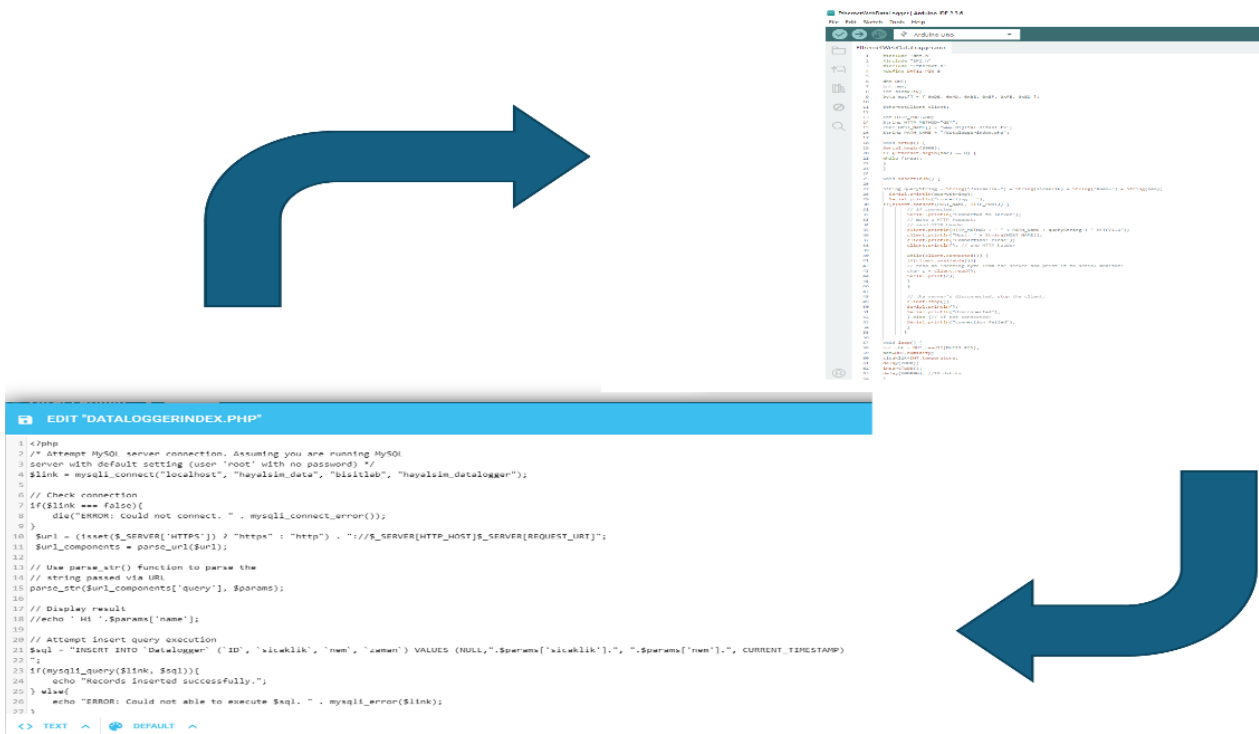
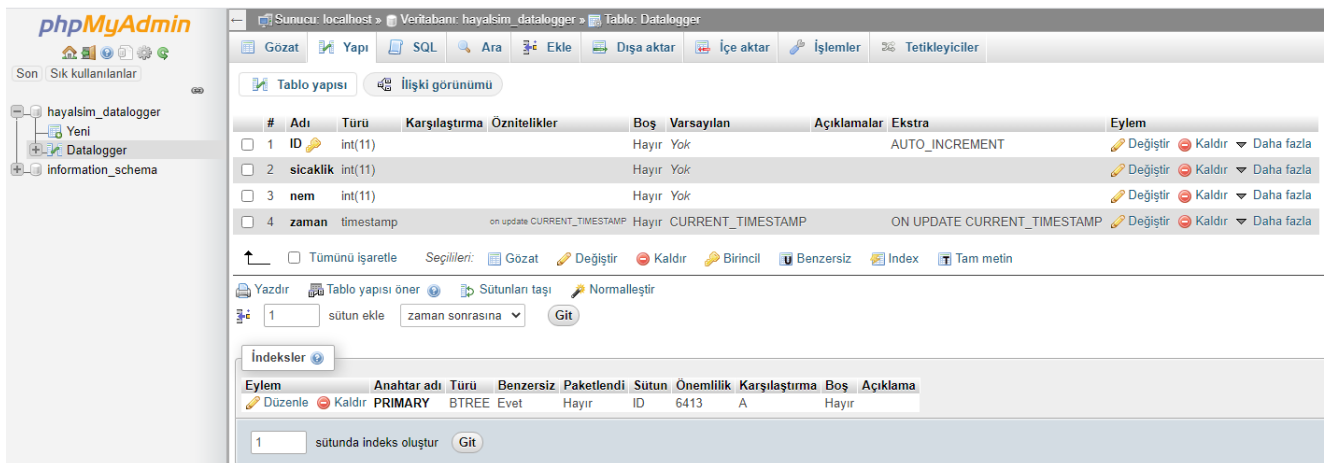


Figure 2. Developed software for microcontroller board and database.

D. Database and Web Interface

A MySQL database was designed to store environmental data transmitted from the Arduino unit. Each record included a timestamp, temperature value,

of sensor data. The database schema is shown in Figure 3, which presents the design of the tables and the relationships between different attributes.



and humidity value. The relational database structure ensured efficient storage, retrieval, and management

Figure 3. MySQL database schema for storing temperature and humidity data.

To enable remote monitoring, a web interface was implemented through PHP integrated with a MySQL database. This platform allowed users to observe environmental conditions in real time and examine historical data records. Using any standard web browser, researchers could access the system from a distance without requiring specialized software.

E. System Installation

After the successful integration of hardware and software components, the system was deployed in the Crop Stress Monitoring and Thermography Laboratory at the Faculty of Agriculture, Çanakkale Onsekiz Mart University (Figure 4). It was configured to record

temperature and humidity data continuously at ten-minute intervals.

The final implementation exhibited consistent data transmission, dependable database storage, and

intuitive access via the web interface, validating the system as an effective and low-cost alternative to commercial monitoring solutions.



Figure 4. Installed device in detail.

III. RESULTS AND DISCUSSION

A. System Performance

The system was successfully installed in the Crop Stress Monitoring and Thermography Laboratory at the Faculty of Agriculture, Çanakkale Onsekiz Mart University. It recorded temperature and humidity data continuously every ten minutes. This continuous operation demonstrated the reliability of both hardware

and software components. Data transfer between the Arduino unit and the MySQL database remained stable, as shown in Figure 5, without any loss of information. Furthermore, the PHP-based web interface allowed researchers to monitor conditions in real time and access historical datasets. These results confirm that the system meets the requirements of controlled environment research, where uninterrupted

ID	sıcaklik	nem	zaman
6410	31	38	2021-08-27 12:56:17
6409	31	38	2021-08-27 12:46:14
6408	31	37	2021-08-27 12:36:11
6407	31	38	2021-08-27 12:26:09
6406	31	38	2021-08-27 12:16:06
6405	31	38	2021-08-27 12:06:03
6404	31	37	2021-08-27 11:55:57
6403	31	37	2021-08-27 11:45:54
6402	31	37	2021-08-27 11:35:51
6401	31	37	2021-08-27 11:25:48

and dependable monitoring is crucial [1, 2].

Figure 5. MySQL database list view.

B. Cost-effectiveness

One of the main results of this study is the overall cost of the system, which was approximately 50 USD for all components. Compared to commercial systems that offer similar functions at much higher prices, this design provides an affordable alternative while maintaining reliability. Using open-source microcontrollers like Arduino reduces dependence on proprietary manufacturer infrastructures and promotes long-term sustainability [10, 12]. Previous studies also emphasize the importance of cost-effective monitoring solutions for laboratories and small-scale agricultural operations [4, 5].

C. Reliability and Data Integrity

Continuous data logging enabled researchers to identify potential changes in environmental conditions that could affect the validity of experiments. The web-based database provided a centralized platform for storing and managing these records. This setup aligns with findings from previous studies on IoT-enabled agricultural systems [8, 14]. Remote access to real-time data further improved the system's usability, allowing researchers to monitor experiments even when they were away from the laboratory.

D. Comparison with Previous Studies

Previous studies have shown that wireless sensor networks and microcontroller-based platforms are effective for monitoring both greenhouses and laboratories [6, 7]. The system presented here emphasizes simplicity, affordability, and modularity, while still providing reliable data storage and visualization. In line with Wang et al. (2006), this study confirms that open-source electronic solutions can be successfully applied in agricultural monitoring without compromising accuracy.

E. Future Prospects

The modular design of the system allows additional sensors—such as those for light intensity, CO₂ concentration, or soil moisture—to be added within the microcontroller's capacity. This flexibility enables the platform to support a wide range of research needs, making it a scalable solution for larger agricultural applications. Future improvements could include cloud-based data storage and advanced analytics to support better decision-making in precision agriculture [3, 7].

IV. CONCLUSION

This study presented the development and implementation of an affordable, web-based data logging system for controlled agricultural environments. Built around an Arduino UNO microcontroller, a DHT11 temperature-humidity

sensor, and an Ethernet shield, the system successfully recorded environmental parameters at ten-minute intervals and stored the data in a PHP-MySQL database accessible through a web interface. The results demonstrated that the system can provide reliable data collection and remote monitoring at a total cost of roughly 50 USD, offering a cost-effective alternative to commercial solutions.

The findings emphasize three key contributions:

Affordability – The system substantially lowers expenses compared to traditional commercial products while maintaining operational reliability.

Reliability – Continuous data logging combined with web-based access ensured precise monitoring of environmental conditions, minimizing the risk of data loss or experimental errors.

Scalability – Its modular architecture allows additional sensors to be incorporated, supporting wider applications in both laboratory and agricultural contexts.

These advantages make the platform particularly valuable for agricultural research laboratories, where precise control and monitoring of environmental factors are essential for experimental success. Furthermore, the study illustrates how open-source microcontroller platforms can enable sustainable and practical solutions in agricultural technology.

Future work could focus on integrating extra sensors, including soil moisture, CO₂ concentration, and light intensity, to broaden the system's monitoring scope. Incorporating cloud-based storage and advanced data analytics could further support precision agriculture practices on a larger scale.

In conclusion, the developed system represents a robust, low-cost, and scalable platform that fulfills the need for reliable monitoring in controlled agricultural settings. By combining affordability, flexibility, and accessibility, it contributes to ongoing efforts to promote sustainable agricultural production and improve research efficiency.

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