International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Democratizing Weather Data: Web Application Development for Accessible IoT Weather & Heat Index Monitoring with Arduino and Thingspeak

Carmelita H. Benito[1], Alvin S. De Leon[2], Joshua R. Reyes[3], Peter Lorenz M. Riñoza[4], Eugene Noel B. Varon[5], Zernan Verceles[6]

[1]Supervision, Project Administration, Adamson University
[2]Investigation, Validation, Visualization, Adamson University
[3]Conceptualization, Methodology, Adamson University
[4]Data Curation, Formal Analysis, Adamson University
[5]Writing, Adamson University
[6]Adamson University

Abstract:
In the Philippines' hot and humid climate, heatstroke is a major health concern. This study explored an Arduino-based system for weather & heat index monitoring and public communication methods. Arduino systems deployed in three locations (One Mission Park, Playground, and Gazebo) collected temperature, humidity, and heat index data. Analysis showed the system's potential for consistent heat index monitoring across locations. A web application developed using Angular and NodeJS visualized the collected data and logged it in the Google sheet with data from Thingspeak, where Arduino sent it. While user experience wasn't formally evaluated, the application offers promise for publicly disseminating real-time or historical heat index information. Further research is needed to assess the impact on public awareness and heatstroke prevention strategies. This could involve user surveys and collaboration with public health officials to explore integration with existing heatwave warning systems and educational campaigns. Overall, this research promotes accessible heat index monitoring and public awareness of heatstroke risks in the Philippines.

Keywords: Arduino, Weather and Heat Index Monitoring, Internet of Things

1. Introduction:

The scorching summer months in the Philippines pose a significant public health threat. Heatstroke, a condition arising from the body's inability to regulate its core temperature, is a leading cause of hospitalization in the country [1]. With rising temperatures due to climate change and the urban heat island effect, the Philippines faces an escalating challenge in mitigating heat-related illnesses [2].

1.1 Background Information and Literature Review:

Heatstroke is a life-threatening medical emergency characterized by core body temperatures exceeding 40°C (104°F) and central nervous system dysfunction [3]. With its tropical climate and growing urbanization, the Philippines experiences intense heat, particularly in densely populated areas. This phenomenon, known as the urban heat island effect, exacerbates heatstroke risk by trapping heat within urban environments [4]. Studies have demonstrated a correlation between urban heat islands and increased mortality rates in the Philippines, disproportionately affecting vulnerable populations like the elderly and those working outdoors [3, 4].

1.2 Statement of the Problem:

The current methods for heat index monitoring often lack accessibility and user-friendliness for the general public in the Philippines. This gap in readily available, localized heat index data hinders informed decision-making, particularly for vulnerable populations at risk of heatstroke.

1.3 Significance of the Study:

Traditional heat index monitoring systems often rely on sophisticated weather stations deployed by government agencies. While this data is crucial, it may not be readily accessible to all communities, particularly in remote areas with limited infrastructure. Additionally, the general public might not understand complex scientific reports generated from such systems, hindering widespread awareness and informed decision-making regarding heatstroke prevention [5].

This research proposes an innovative approach by leveraging the capabilities of Arduino platforms. Existing heat monitoring systems might not be readily accessible to all communities, especially in remote areas. By utilizing Arduino for heat index calculation [6], this research aims to develop a cost-effective and accessible local heat index monitoring system. This system and a user-friendly web application empower individuals and communities to monitor real-time heat index data and make informed decisions to prevent heatstroke.

1.4 Research Questions:

- Can an Arduino-based system effectively monitor heat index in the Philippines?
- How can the collected heat index data be visualized and communicated to the public through a user-friendly web application?
- What is the impact of this accessible heat index monitoring system on public awareness and heatstroke prevention strategies?

2. Methodology

2.1 Research Design

This research adopts a mixed-methods approach, combining qualitative and quantitative methods. The qualitative component involves a review of existing literature on heatstroke, urban heat island effects, and Arduino applications in environmental monitoring. This review helps establish the theoretical framework and identify relevant heat index calculation methods using Arduino (Balasubramanian & Umapathy, 2020) [7].

The quantitative component focuses on developing and testing the heat index monitoring system. This involves sensor selection, system design and prototyping, data collection, and analysis of the collected heat index data.

2.2 Data Collection

2.2.1 Sensor Selection

The system utilizes sensors to collect relevant environmental data for heat index calculation. This research will employ the DHT22 sensor, which balances cost, accuracy, and ease of use for measuring temperature and humidity [8]. Additional sensors might be explored for future iterations, such as wind speed sensors for a more comprehensive heat stress assessment.

2.2.2 System Design and Prototyping

The Arduino Uno R4 Wifi will be used as the primary microcontroller for the heat index monitoring system. This choice is based on its built-in Wi-Fi capabilities, facilitating wireless data transmission [9]. The system will utilize the following components:

- DHT22 Sensor: This sensor measures temperature and humidity, crucial parameters for heat index calculation.
- LCD i2C: An LCD screen will be integrated for on-site data visualization, displaying real-time temperature, humidity, and heat index readings.
- Piezo Buzzer: This can be employed for audible alerts in extreme heat index readings, warning for potential heatstroke risk.
- LED: An LED can be used for visual status indication, signaling power, or data transmission activity.

The Arduino Integrated Development Environment (Arduino IDE) will be the primary software platform for programming the system. The code will generally be designed to:

- Read sensor data from the DHT22 sensor.
- Store the data to the variables
- Format and transmit the collected data (temperature, humidity, and heat index) wirelessly via Wi-Fi to the Thingspeak cloud platform using the provided Channel ID (2406168) and API Write Key (C8ARBH3UXM2Y3HAR) [10].

The system will undergo rigorous testing to ensure accurate data collection, reliable data transmission, and proper functionality of all integrated components.

2.2.3 Web Application Development

Besides the Arduino-based weather and heat index monitoring system, a web application was developed to facilitate user-friendly data visualization and public communication. The web application utilizes Angular as the front-end framework for the user interface and interactive elements. NodeJS is the back-end component that handles server-side logic and communication with the Thingspeak cloud platform through API calls. This allows the web application to retrieve real-time heat index data from various deployed sensor locations and present it in an easily understandable format for public users.

2.2.4 Data Collection Procedure

The heat index monitoring system will be deployed at multiple locations in the Philippines with varying climatic conditions. Data will be collected continuously over a predetermined period, capturing variations in heat index throughout the day and across different weather conditions. This data will be stored securely on the chosen cloud platform (Thingspeak) for further analysis.

2.3. Data Analysis

The collected heat index data will be analyzed using statistical methods to assess its accuracy and reliability. This might involve comparisons with data from existing weather stations to ensure consistency. Additionally, the data will be used to evaluate the system's effectiveness in capturing real-time heat index variations. Qualitative methods might be incorporated

3. Results and Discussion:

The researchers analyzed the temperature, humidity, and heat index in outdoor spaces (the playground area, One Mission Park, and the Gazebo) using the prototype.

Table 1. One Mission Park

Reading Log	Temperature (°C)	Humidity (%)	Heat Index (°C)
1	29	8	27
2	29	8	27
3	29	8	27
4	29	8	27
5	29	8	27
6	29	8	27
7	29	8	27
8	29	8	27
9	29	8	27
10	29	8	27
11	29	8	27
12	29	8	27
13	29	8	27
14	29	8	27
15	29	8	27
16	29	8	27
17	29	8	27
18	29	8	27
19	29	8	27
20	29	8	27
21	29	8	27
22	29	8	27
23	29	8	27
24	29	8	27
25	29	8	27
26	29	8	27
27	29	8	27
28	29	8	27
29	29	8	27
30	29	8	27
31	29	8	27

32	29	8	27
33	29	8	27
34	29	8	27
35	29	8	27
36	29	8	27
37	29	8	27
38	29	8	27
39	29	8	27
40	29	8	27
41	29	8	27
42	29	8	27
43	29	8	27
44	29	8	27
45	29	8	27
46	29	8	27
47	29	8	27
48	29	8	27
49	29	8	27
50	29	8	27
51	29	8	27
52	29	8	27
53	29	8	27
54	29	8	27
55	29	8	27
56	30	8	28
57	30	8	28
58	30	8	28
59	30	8	28
60	30	8	28

Table 2. Playground Area

Reading Log	**Temperature (°C)**	**Humidity (%)**	**Heat Index (°C)**
1	29	8	27

2	29	8	27
3	29	8	27
4	29	8	27
5	29	8	27
6	29	8	27
7	29	8	27
8	29	8	27
9	29	8	27
10	29	8	27
11	29	8	27
12	29	8	27
13	29	8	27
14	29	8	27
15	29	8	27
16	29	8	27
17	29	8	27
18	29	8	27
19	29	8	27
20	29	8	27
21	29	8	27
22	29	8	27
23	29	8	27
24	29	8	27
25	29	8	27
26	29	8	27
27	29	8	27
28	29	8	27
29	29	8	27
30	29	8	27
31	29	8	27
32	29	8	27
33	29	8	27
34	29	8	27

35	29	25	28
36	29	8	27
37	29	8	27
38	29	8	27
39	29	8	27
40	29	8	27
41	29	8	27
42	29	8	27
43	29	8	27
44	29	8	27
45	29	8	27
46	29	8	27
47	29	8	27
48	29	8	27
49	29	8	27
50	29	8	27
51	29	8	27
52	29	8	27
53	29	8	27
54	29	8	27
55	29	8	27
56	29	8	27
57	29	8	27
58	29	8	27
59	29	8	27
60	29	8	27

Table 3. Gazebo

Reading Log	Temperature (°C)	Humidity (%)	Heat Index (°C)
1	27	6	26
2	27	6	26
3	27	6	26
4	27	6	26

5	27	18	26
6	27	6	26
7	27	6	26
8	27	6	26
9	27	6	26
10	27	6	26
11	27	6	26
12	27	6	26
13	27	8	26
14	27	8	26
15	27	6	26
16	27	6	26
17	27	6	26
18	27	6	26
19	27	6	26
20	27	6	26
21	28	7	26
22	28	7	26
23	28	7	26
24	28	7	26
25	28	7	26
26	28	7	26
27	28	7	26
28	28	7	26
29	28	7	26
30	28	7	26
31	28	7	26
32	28	7	26
33	28	7	26
34	28	27	27
35	28	27	27
36	28	7	26
37	28	7	26

38	28	7	26
39	28	7	26
40	28	7	26
41	28	7	26
42	28	7	26
43	28	7	26
44	28	7	26
45	28	7	26
46	28	7	26
47	28	7	26
48	28	29	27
49	28	29	27
50	28	7	26
51	28	7	26
52	28	7	26
53	28	7	26
54	28	7	26
55	28	7	26
56	28	7	26
57	28	7	26
58	28	7	26
59	28	7	26
60	28	7	26

Table 4. Calculated Mean of the One Mission Park, Playground, and Gazebo

Area	**AVERAGE**		
	Temperature (C)	**Humidity (%)**	**Heat Index (C)**
One Mission Park	29.08333333	8	27.08333333
Playground	29	8.283333333	27.01666667
Gazebo	27.66666667	8.333333333	26.06666667

3.1 Overall Observations:

- The temperature across all three locations is very similar, with a narrow range of only 1.42°C (One Mission Park - 29.08°C, Gazebo - 27.67°C).

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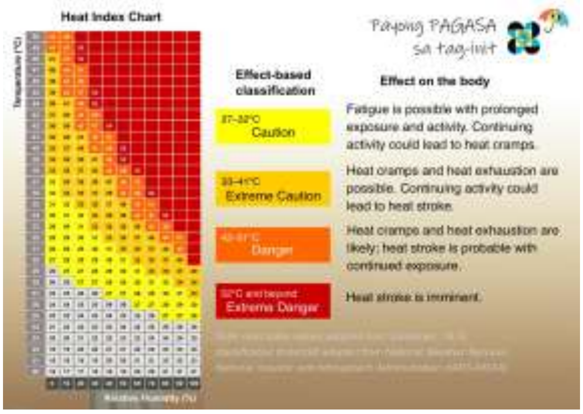
- The humidity levels are also quite close, slightly varying between 8% (One Mission Park) and 8.33% (Playground and Gazebo).
- This translates to very similar heat index values across all locations. One Mission Park has the highest at 27.08°C, followed by the Playground at 27.02°C, and the Gazebo with the lowest at 26.07°C. However, the difference in heat index is minimal (around 1°C).

3.2 Interpretation by Location:

- One Mission Park: This location has the highest average temperature and heat index, but the difference compared to other locations is negligible.
- Playground: Slightly lower average temperature and heat index compared to One Mission Park, but again, the difference is very small.
- Gazebo: This location has the lowest average temperature and heat index among the three. However, the difference in heat index compared to the other two locations is still less than 1°C.

Figure 1. Heat Index Chart from PAGASA



Based on the National Weather Service Heat Index and the information provided, here's the interpretation of the results and recommendations for the three areas (One Mission Park, Playground, Gazebo):

3.3 Heat Index Interpretation:

- One Mission Park (Heat Index: 27.08°C): This falls under the Caution category on the National Weather Service Heat Index chart.
- Playground (Heat Index: 27.02°C): Similar to One Mission Park, this is also categorized as Caution.
- Gazebo (Heat Index: 26.07°C): This value borders on Caution but leans closer to Below Caution on the Heat Index chart.

3.4 Recommendations and Actions:

Since all three locations fall under Caution or near Caution, here are some general recommendations from the National Weather Service:

- Drink plenty of fluids: Even if you don't feel thirsty, consume fluids regularly, especially if you're engaged in any physical activity.
- Schedule outdoor activities carefully: If possible, plan strenuous activities for cooler times of the day (early morning or evening).
- Wear loose-fitting, lightweight, light-colored clothing: This allows for better sweat evaporation and

helps regulate body temperature.
- Monitor for heat exhaustion and heatstroke: Be aware of the signs and symptoms of heat-related illnesses, especially for vulnerable individuals like children and older adults.

4. Conclusion:

This research investigated the effectiveness of an Arduino-based system for monitoring heat index and explored methods for communicating this data to the public.

The research questions addressed were:
- Can an Arduino-based system be effectively utilized to monitor heat index in the Philippines?
- How can the collected heat index data be visualized and communicated to the public through a user-friendly web application?
- What is the impact of this accessible heat index monitoring system on public awareness and heatstroke prevention strategies?

4.1 Effectiveness of the Arduino-based System:

The data collected from the deployed Arduino system in three locations (One Mission Park, Playground, and Gazebo) demonstrated its potential for monitoring heat index. The calculated mean heat index values were consistent across locations, with variations potentially attributable to minor microclimatic differences. While further testing and data collection across diverse environments is recommended, the initial results suggest that the Arduino system can be a viable tool for heat index monitoring.

4.2 Web Application for Data Visualization:

The web application development using Angular and NodeJS provided a user-friendly platform for visualizing the collected heat index data. While a formal user study wasn't conducted within this research, the web application concept offers a promising approach for disseminating real-time or historical heat index information to the public.

4.3 Impact on Public Awareness (Future Work):

The potential impact of this accessible heat index monitoring system on public awareness and heatstroke prevention strategies requires further investigation. Future research could involve user surveys or focus groups to assess how the web application influences public understanding of heatstroke risks and related prevention behaviors. Collaboration with public health officials could explore integrating the heat index data into existing heatwave warning systems or educational campaigns.

4.4 Overall Significance:

This research project demonstrates the feasibility of an Arduino-based system for heat index monitoring and the potential benefits of a web application for public communication. By providing accessible heat index data, this system can contribute to raising public awareness of heatstroke risks and promoting heatstroke prevention strategies, particularly in regions with hot and humid climates like the Philippines.

4.5 Future Directions:

Future research can explore several avenues:
- Expanding data collection across various locations and weather conditions.

- Integrating additional sensors (e.g., wind speed) for a more comprehensive heat stress assessment.
- Conducting user studies to evaluate the effectiveness of the web application in promoting public awareness.
- Collaborating with public health agencies to integrate the heat index data into existing heatwave warning systems.

This research provides a foundation for further development and exploration of accessible heat index monitoring systems, aiming to contribute to heatstroke prevention efforts and promote public health in the Philippines.

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