Smart Iot Device for Weather And Health

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DOI: https://doi.org/10.51244/IJRSI.2025.120800048

Received: 30 July 2025; Accepted: 04 August 2025; Published: 02 September 2025

ABSTRACT

This project shows an IoT Weather and Health Monitoring System based on the Raspberry Pi Pico W to monitor essential health parameters and environmental factors in real-time. It includes a BME280 sensor for temperature, humidity, and pressure, an MQ135 sensor for monitoring air quality, a Ds18b20 body temperature sensor, and a MAX30100 pulse oximeter and heart rate sensor for heart rate, SpO_2 level, and body temperature measurements. An OLED screen offers in-device feedback, and IoT connectivity along with a GSM module offers remote monitoring and real-time SMS alerting for emergency alerts like high fever, low air quality, dehydration hazard, and altitude-related oxygen shortage. The MQ135 sensor offers more environmental sensitivity through pollutant detection, which makes the system very useful for users in environments with low air quality. The GSM module guarantees alerts are sent even in areas with poor internet connectivity. The intelligent IoT prototype is suitable for outdoor enthusiasts, the elderly, and patients with respiratory or cardiovascular diseases, providing real-time monitoring of health, environment, and emergency alerts. Future upgrades could involve AI-powered predictive analytics, integration with mobile health apps, and cloud data logging for long-term trend identification and enhanced emergency response.

Keywords— IoT, Raspberry Pi Pico W, BME280, MAX30100, GSM, Health Monitoring, Air Quality.

INTRODUCTION

The development of Internet of Things (IoT) technology has made it possible to create smart health and environmental monitoring systems that offer real-time access to data and alerting capabilities. This work describes an IoT Weather and Health Monitoring System based on the Raspberry Pi Pico W, intended to monitor environmental factors like temperature, humidity, pressure, and air quality in real-time, and vital health indicators like heart rate, SpO_2, and body temperature. The system utilizes several sensors like the BME280 for weather conditions, MQ135 for air quality, MAX30100 for pulse oximeter, and MAX30205 for body temperature monitoring.

One of the major features of this system is its OLED screen, which gives real-time indications, and wireless IoT connectivity, allowing remote access of data through cloud platforms. Also, an integrated GSM module keeps warnings going through SMS notifications even in locations with limited internet connectivity. The system is specifically valuable to outdoor users, older adults, and patients with respiratory or cardiovascular diseases, providing constant surveillance and emergency notification.

This paper addresses the hardware implementation of the system, integration with IoT, and real-time alerting mechanisms, followed by a comparative study with current models. Future improvements, including AI-driven predictive analytics and integration with mobile health apps, are also discussed to enhance the accuracy and usability of the device.

LITERATURE OVERVIEW

Using the ESP32 microcontroller, Dey and Bera created an Internet of Things system that gathers physiological and environmental data, including temperature, humidity, and heart rate, and sends it over Wi-Fi to a cloud server [1]. The system's main strength is in educational settings, where it provides a hands-on introduction to embedded systems and sensor integration, even though it enables applications like fitness tracking and home automation. The ESP32 is a good choice for multipurpose Internet of Things devices because of its integrated connectivity and energy economy.

By using the BME280 sensor in airflow and respiratory investigations, Shevchenko et al. demonstrated the sensor's greater potential than traditional environmental sensing [2]. They demonstrated the sensor's versatility in biomedical applications by incorporating it into a small wearable gadget for determining the temperature and humidity of the nasal passages.

An ESP32-based health monitoring system was proposed by Farej and Al-Hayaly [3] to track vital signs such as heart rate and SpO_2. In the context of senior care, this solution provides healthcare providers with continuous and real-time data to identify health issues early on. It can be used in remote healthcare applications because of its wireless connection and low power consumption.

A mobile-based health self-monitoring system designed to assist patients in tracking and reporting their health condition, was introduced by Yusuf et al. [4]. In order to enhance illness prevention and control, the system enables synchronization between patients and medical providers and shows patient data graphically.

In order to measure meteorological factors such as temperature and humidity, Qasim et al. proposed an Internet of Things-based weather monitoring system that makes use of the ESP32 and Blynk platform [5]. The system highlights the benefits of real-time analysis and visualization of data via cloud-based transmission and visualization, as well as its possible application in environmental forecasting, aviation, and agriculture.

In order to operate appliances using environmental inputs such as temperature, humidity, and gas concentrations, Hanah et al. created a smart control system that uses a Raspberry Pi [6]. By automating interior condition adjustments, the system offers the user increased convenience and safety, underscoring the importance of the Internet of Things in smart home automation.

HARDWARE OVERVIEW

Raspberry pi pico w

The Raspberry Pi Pico W is the brain of this IoT-based weather and health monitoring system, responsible for real-time processing of sensor data and communication. It has a dual-core ARM Cortex-M0+ processor and integrated WiFi allowing end-to-end IoT integration for remote monitoring. The Pico W gathers readings from the BME280 (pressure, temperature, humidity), MQ135 (air quality), MAX30205 (body temperature), and MAX30100 (heart rate and SpO_2 sensor) and shows output on an OLED display. Critical conditions such as high fever, poor air quality, or lack of oxygen trigger SMS notifications from a GSM module. Its low power requirements, multiple I/O pins, and wireless feature make it suited for portable real-time environmental and health monitoring uses in remote or urban locations.

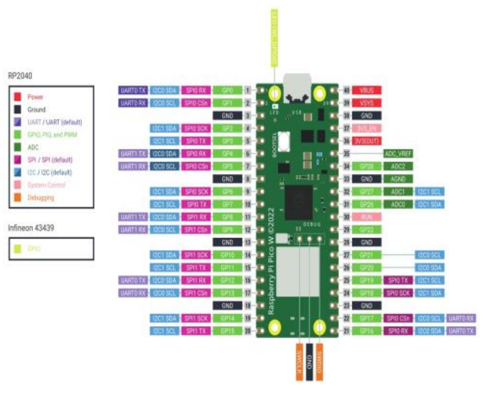

Fig 1. Pico W Pin Diagram

INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

BME/BMP280

The BME280/BMP280 sensor is a high-accuracy environmental sensor utilized in this IoT-based system for monitoring weather and health to sense temperature, humidity (in BME280), pressure, and altitude. It gives precise atmospheric pressure readings, which are necessary to sense changes in the weather and changes in altitude. The sensor interacts with the Raspberry Pi Pico W through I²C or SPI, providing glitch-free data collection for real-time monitoring. Altitude is determined by the barometric formula, which approximates height from pressure differences . As atmospheric pressure lowers with altitude, the sensor compares sea-level pressure to calculate the user's elevation. This is especially helpful in high-altitude health monitoring, where lower oxygen levels can affect SpO_2 readings. With the inclusion of BME280/BMP280, the system will be able to provide altitude-related health warnings, including oxygen insufficiency alarms when at higher altitudes, which would be beneficial for outdoor enthusiasts, hikers, and people with respiratory ailments.

Fig 2. BME Environmental Sensor

GY-MAX30102

The GY-MAX30102 is a high-accuracy optical sensor employed in this IoT-based health and weather monitoring system to track heart rate, SpO_2 (blood oxygen saturation level), and the intensity of the pulse. It uses photoplethysmography (PPG), where infrared and red light-emitting diodes (LEDs) measure changes in the blood flow. The sensor is connected to the Raspberry Pi Pico W through I²C, which delivers efficient real-time health tracking. Its power consumption is low, which makes it suitable for portable and wearable devices. In this project, the GY-MAX30102 facilitates the measurement of oxygen levels, particularly in high-altitude or contaminated environments as picked up by the BME280 and MQ135 sensors. It provides key alerts for hypoxia, irregular heart rate, and potential health hazards, making it essential for outdoor lovers and people suffering from respiratory illnesses.

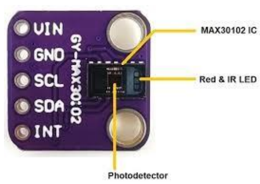

Fig 3. GY- Max30102 Sensor

DS18B20

The DS18B20 is a digital temperature sensor utilized in this weather and health monitoring IoT-based system to capture accurate body or ambient temperature. It talks to the Raspberry Pi Pico W through the 1-Wire protocol, making it possible to use multiple sensors on one data line. It has a range of -55°C to 125°C and accuracy of ±0.5°C, which provides accurate readings. In this project, the DS18B20 assists in tracking body temperature for fever detection and cross-references environmental conditions from the BME280 sensor. Through its integration, real-time alarms for high fever or extreme ambient temperatures are enhanced, providing increased health and safety monitoring.

Fig 4. DS18B20

MQ135

The The MQ135 air quality sensor has been utilized here in the IoT-based weather monitoring and health surveillance system to measure toxic gases like carbon dioxide, ammonia, benzene, and smoke. It works by sensing variations in electric resistance with gas concentration and supplies analog output to the Raspberry Pi Pico W. The sensor assists in monitoring air pollution levels, which allow for early alerting for unfavorable air quality impacting respiratory health. Here, it collaborates with the BME280 and MAX30102 to map environmental conditions to health parameters, producing alerts for excessive pollution levels that may affect patients with respiratory or cardiovascular diseases.

Fig 5. MQ135 Sensor

GSM module

The The GSM module in this IoT-based weather and health monitoring system enables real-time SMS notifications for critical alerts. It connects with the Raspberry Pi Pico W via UART, allowing the system to send emergency messages for conditions like high fever, poor air quality, or oxygen deficiency. This ensures users receive alerts even in areas without internet access, making the system ideal for remote health and environmental monitoring applications.

Fig 6. GSM Module

OLED display

OLED display is a key part of the IoT-based weather and health monitoring system, offering real-time visual feed back on sensor information. It is a low power, high contrast display that is connected to the Raspberry Pi Pico W using I^2C or SPI. It shows major health parameters like heart rate, SpO_2, and body temperature, and environmental parameters like temperature, humidity, pressure, altitude, and air quality. This enables instant checking of the health status and environment without the need for external devices. The screen provides improved user experience through clear and readable alerts for life-threatening health or environmental hazards.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Fig 7. OLED Display

MQ-2

The MQ-2 gas sensor is a general-purpose low-cost sensor employed for the detection of various gases such as smoke, methane, LPG, and hydrogen. For this IoT weather and health monitoring project, the MQ-2 can be utilized as another environmental sensor to aid in air quality measurement. It detects a change in the concentration of gas and gives an analog output signal readable by the Raspberry Pi Pico W. Including the MQ-2 makes it possible to sense the potential toxic gas leakage or smoke status, offering alerts for safety with other environmental feedback. When gas concentrations reach a specified level, the system can provide alerts on the OLED screen and issue real-time alerts through GSM or IoT platforms, enhancing the device's capability to detect air quality in sensitive environments.

Fig 8. MQ2 Sensor

SOFTWARE OVERVIEW

Arduino IDE

Writing, compiling, and uploading C/C++ code to microcontrollers like the Raspberry Pi Pico W is made simple by the Arduino Integrated Development Environment (IDE), a free and user-friendly platform. Its straightforward interface is ideal for both novices and specialists, and it eliminates the need for complex configurations to integrate and program a variety of sensors, including the BME280, MQ135, and GY-MAX30102. The application of alert logic, data presentation on OLED screens, and sensor connectivity are all made simple by the IDE's broad library support. Before adding GSM and IoT capabilities, sensor threshold levels needed to be calibrated and debugged in real-time using the Serial Monitor included in the IDE.

Fig 9. Interface of Arduino IDE Software

MTI APP Interface

The Massachusetts Institute of Technology developed MIT App Inventor, a user-friendly visual programming platform that enables users to create fully functional Android apps using a drag-and-drop, block-based approach. This platform is ideal for projects involving IoT microcontrollers and sensors. It was used in this case to develop a mobile application that displays health and environmental data collected in real time by

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

sensors (BME280, MQ135, and GY-MAX30102) that are interfaced to the Raspberry Pi Pico W. Utilizing the Pico W's built-in Wi-Fi, the device can function as a local HTTP server, allowing the app to retrieve data through recurring GET queries, or it can send data to cloud platforms like ThingSpeak or MQTT brokers, enabling worldwide accessibility through API calls or subscriptions.

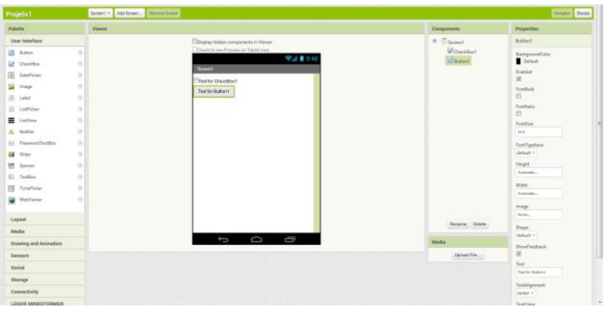

Fig 9. MTI APP Inventor Software interface

In order to clearly present sensor data and respond to threshold violations, the program uses dynamic user interface components such as labels, graphs, and warnings. This makes the system responsive and interactive. Because of its ease of use, quick iteration cycle, and compliance with online and cloud APIs, MIT App Inventor is a powerful tool for creating customized, platform-neutral mobile interfaces for remote health and environmental status monitoring. These interfaces are ideal for low-cost, practical, and instructional Internet of Things applications.

DESIGN OF THE SYSTEM

System Development

An huge suite of hardware, software, and cloud components that provide real-time data collecting, visualization, and remote monitoring are all part of the design of this Internet of Things-enabled health and environmental monitoring system. At its core is the Raspberry Pi Pico W, which uses the Arduino IDE and MicroPython to manage sensor data collecting, processing, and cloud connectivity. The BME280 sensor records environmental elements including temperature, humidity, and pressure, while the GY-MAX30105 sensor uses photoplethysmography to track vital health indicators like heart rate and SpO_2. Both sensors communicate over I2C for the best data handling.

An SSD1306 OLED display provides real-time feedback with live readings, and the inbuilt Wi-Fi module makes it simple to connect to cloud platforms like ThingSpeak or Blynk for data logging and remote monitoring. The resulting custom mobile application, developed using MIT App Inventor, enhances user interactions and accessibility by graphically displaying real-time data on the screen and sending out notifications when thresholds are crossed. Component selection, hardware hardening, application development for sensor control and cloud connection, and rigorous real-time debugging for accuracy, connectivity, battery life, and user reaction are all meticulously followed in the design process. Continuous data analysis and long-term environmental and health status monitoring are made possible by this all-inclusive design, which offers a reliable, easily navigable, and user-friendly solution tailored for personal, healthcare, and industrial applications.

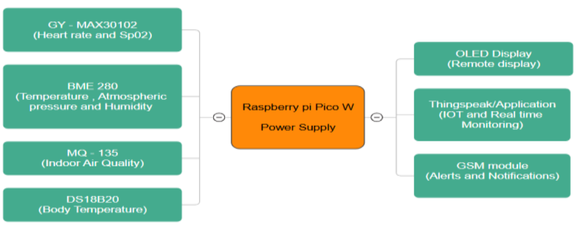

Fig 10. Block Diagram of Environmental and Health Monitoring

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

The Raspberry Pi Pico W, the brains behind the Internet of Things-based weather and health monitoring system, collects and analyzes real-time sensor data. The BME280 measures temperature, humidity, pressure, and altitude; the MQ135 measures hazardous gases to gauge air quality; the MAX30102 measures heart rate and SpO_2; and the DS18B20 measures the ambient temperature accurately. For immediate feedback, processed data is shown on an OLED panel. When thresholds are achieved, a GSM module sends out SMS messages, enabling offline notification. In order to allow users to watch live readings, receive notifications, and see trends remotely, the Pico W simultaneously transmits data to a mobile app created with MIT App Inventor. This device is ideal for environmental and health monitoring in a range of real-world settings since it is compact, portable, and power-efficient.

Hardware Development

The hardware architecture of an Internet of Things-enabled weather and health monitoring system built on the Raspberry Pi Pico W microcontroller is seen in Figure. The system uses a number of sensors to collect physiological and environmental data in real time. While the GY-MAX30102 module is intended to measure vital indicators including heart rate and blood oxygen saturation (SpO_2), the MQ135 and gas sensors are used to assess the quality of the air. The BME280 sensor gathers environmental data like temperature, humidity, and atmospheric pressure. Stable voltage regulation is provided throughout the system via a dependable power supply module.

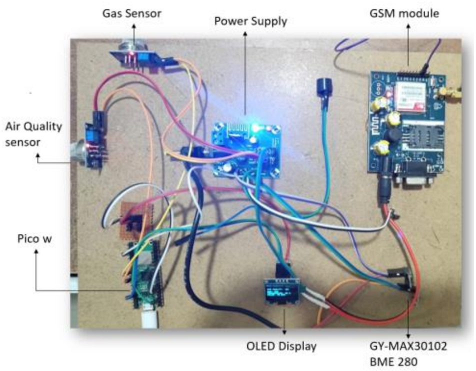

Fig 11. Hardware Connections

Instant feedback in the form of sensor information such as air quality index, pulse rate, SpO_2, and atmospheric conditions is provided by an OLED display module that can be accessed via the I^2C protocol. Additionally, the device may operate even in the absence of internet connectivity thanks to a GSM module that enables wireless communication by sending out SMS warnings when predefined thresholds are exceeded, such as declining air quality or abnormal vitals.

Fig 12. OLED Displaying Title

"Weather & Health Monitoring System" is the initial title screen that the OLED panel displays upon successful system activation and data gathering readiness, as shown in Figure. An implementation of a 0.96-inch I^2C OLED display provides high contrast, small, and power-efficient local visualization for embedded

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applications. Under typical circumstances, the OLED dynamically shows sensor data in real time, enhancing situational awareness and usability. Together, the local visualization and the GSM module's remote monitoring feature offer an interactive, ambulatory approach to environmental and health monitoring. In line with the objectives of creating a reliable IoT-based monitoring system for remote and resource-constrained locations, the actualized design demonstrates an effective trade-off between real-time feedback, power-saving operation, and dependable communication.

The IoT-based Weather and Health Monitoring System's OLED screen provides a quick, real-time view of physiological and environmental data on the device. By utilizing the I²C protocol to interface with the Raspberry Pi Pico W, the OLED eliminates the need for extra hardware by providing vital information instantly, including temperature, heart rate, gas detection, and air quality. For instance, a number of "AIR QUALITY" of about 91 suggests a somewhat safe air quality, whereas a value of "GAS: YES" indicates the presence of dangerous gases as detected by sensors like the MQ135 or MQ2.

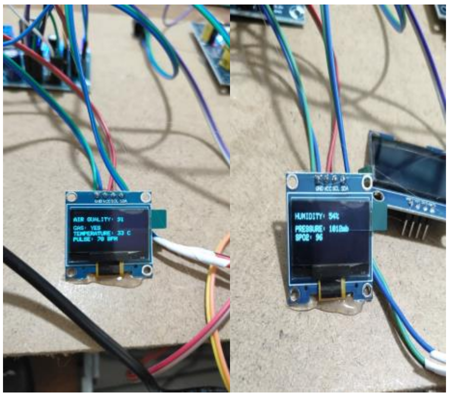

Fig 13. OLED Readings Display

Sensors like the BME280 or DS18B20 are used to measure the temperature, which is typically approximately 33°C. A normal resting heart rate of 70 BPM is likewise displayed by the GY-MAX30102 module.

The display further displays blood oxygen saturation, humidity, and atmospheric pressure to supplement these readings and provide the user with a more comprehensive view of their surroundings and well-being. The BME280 sensor measures typical atmospheric pressure (e.g., 1012 mb) and safe humidity levels (e.g., 54%). The MAX30102 measures SpO_2, and a value of 96% indicates normal oxygenation. This in-device visualization's real-time nature enhances user involvement by providing immediate feedback and confirming the live operation of all onboard sensors. The system is positioned as an effective option for mobile health diagnostics, environmental monitoring in sensitive areas, and wellness tracking in customized situations because it enables both local and distant monitoring when combined with GSM and IoT characteristics.

Software Development

The IoT-based Weather and Health Monitoring System's mobile app, developed with MIT App Inventor, provides a real-time interface. The software, which is easy to use and accessible, shows the vital health and environmental data collected by sensors that are connected to the Raspberry Pi Pico W. The interface clearly displays important information including temperature, air quality index, and gas presence. For example, "GAS: NO" indicates that there are no hazardous gases present, and the air quality index reading of 122 indicates that the conditions are moderately safe. Sensors like the DS18B20 and the BME280 are used to measure the temperature, which comes out to 32°C. Sometimes, parameters like "HB" (heart rate) and "SPO" (SpO_2) will display "NF" (Not Found). This typically occurs when the corresponding sensor is not on the user or fails to detect a valid reading.

The mobile app also displays other environmental parameters, such as atmospheric pressure and altitude. The BME280 sensor provides "PRESSURE: 951.73 mb" and "ALTITUDE: 525.25 m" type readings, which are useful for environmental monitoring in health-sensitive settings or for usage in environmental research applications. The app's simple layout makes it simple to use, and it's straightforward to grasp real-time data.

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The Raspberry Pi Pico W uses Wi-Fi based on HTTP or MQTT protocols to communicate with the program, allowing for continuous and incredibly smooth data flow.

Fig 14. App Interface Showing Real time Data

The device's integrated GSM module provides real-time SMS notifications straight to the user's mobile phone to enhance system responsiveness. These alerts provide the user with immediate feedback on the most critical environmental and health parameters, such as "No Gas," "Oxygen Level is Normal," and "Air Quality is Normal." This SMS feature is especially useful in areas without internet access because it gives users a reliable way to get information about their surroundings and health. The combination of SMS alerting and smartphone display greatly expands the system's use, making it suitable for distant, real-time weather and health monitoring.

Alerts and Notifications

A GSM module is integrated into the hardware configuration to further increase the system's dependability in areas with little to no internet connectivity. No matter the connectivity level, this module makes sure consumers are informed on time by sending instant messages via SMS via the mobile network.

Fig 15. Alert Messages

In remote or rural locations, the system is significantly more successful with GSM included. The system instantly issues alerts in the event of abnormal readings, such as the identification of hazardous gases or unusual vital signs, enabling users to take immediate remedial or preventive action. These early alerts are crucial for safeguarding human health and the environment.

An automated SMS message that was set off when gas was discovered in the monitored environment serves as an example of one such feature. The gadget continuously tracks physiological and environmental variables,

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

sending out notifications when they deviate from acceptable bounds. The GSM module's ability to provide real-time emergency notice is demonstrated by the direct SMS "Alert! Gas detected" that is sent to the user's mobile phone. This feature not only helps to guarantee user safety but also highlights how important it is to integrate mobile network-based warnings into IoT systems for vital environmental monitoring.

Fig 16. Abnormal pulserate Alert

The GY-MAX30105 sensor uses red, green, and infrared LEDs to detect variations in light absorption caused by blood flow, enabling precise monitoring of pulse rate and oxygen saturation. The system, which is controlled by the Raspberry Pi Pico W, offers a wireless, portable, low-power solution for ongoing health monitoring. When a GSM module is included, alerts can be safely transmitted over cellular networks, which is particularly helpful in areas with poor or nonexistent internet connectivity.

With potential applications in field operations, geriatric care, rural healthcare, and fitness monitoring, it enables real-time emergency notifications and active health monitoring.

The system might say something like, "You have an irregular pulse rate," for example, if it detects an irregular pulse rate. Now take a nap and stay hydrated. Get checked out by a doctor if the symptoms persist, promoting prompt awareness and action.

RESULTS

Sensor calibration, power management, and network stability were among the technological challenges encountered during the deployment of the Internet of Things-based Weather and Health Monitoring System. The accuracy of physiological and environmental data under various settings was affected by minor fluctuations, so it was crucial to properly calibrate sensors such the MAX30105 and BME280. Another concern was power consumption, especially for mobile use. This was addressed by implementing sensor activity areas or modes that conserve energy during periods of low demand. For smooth data transfer to the cloud for real-time monitoring and alerting, a constant and reliable Wi-Fi connection was also required.

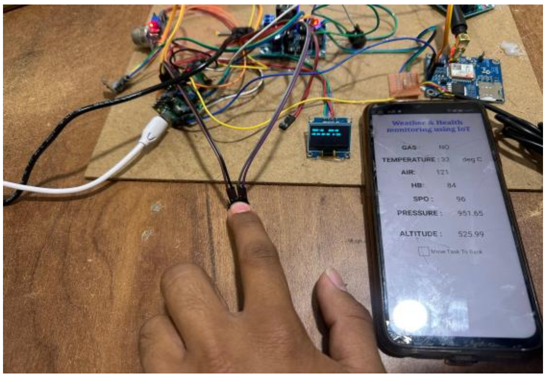

Fig 17. Implemented Results

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

The Raspberry Pi Pico W microcontroller and several sensors are used in the system prototype to measure physiological and environmental parameters in real time. It records data on temperature, atmospheric pressure, heart rate, blood oxygen levels, and air quality. It then processes the data and wirelessly transmits it to a smartphone app over HTTP or MQTT protocols. The Pico W is perfect for environmental and health monitoring applications because of its built-in Wi-Fi capability, which enables real-time remote monitoring.

The primary sensors are the MQ-135 for gas sensing, the BME280 for temperature and pressure, and the GY-MAX30105 for optical sensing of heart rate and SpO_2. Instant health information is provided via readings like a heart rate of 84 BPM and a SpO_2 of 96%. This combination of physiological and environmental data makes it easier to employ in field testing, geriatric care, and rural healthcare.

CONCLUSION

The proposed Internet of Things (IoT)-based health and environmental monitoring system, created with the Raspberry Pi Pico W, has a variety of sensors, including the MAX30105 for heart rate and SpO_2 monitoring, the BME280 for temperature, humidity, and pressure monitoring, the MQ135 for air quality assessment, and the DS18B20 for precise temperature readings. Continuous, real-time data collection and processing in a portable, power-efficient format are made possible by the gadget. While a GSM module allows SMS notice delivery in the event of critical health or environmental situations, an integrated SSD1306 OLED screen facilitates on-device feedback and ensures continuous communication even in the absence of internet connectivity.

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