Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, May : 2024

Experimental Analysis of Weather Monitoring system using NodeMCU and Thingspeak

K.Kalyan Kumar[1], P.Ravi Shankar[2], G.Harika[3], R.Thirumala[4], S.Yuvaraj[5]
1. Assistant Professor, EEE department, KSRMCE(A), Kadapa, AP
2,3,4,5 – UG scholars, EEE department, KSRMCE(A), Kadapa, AP

Abstract: In today's global landscape, understanding real-time environmental conditions poses significant challenges, particularly in live data collection. This project presents a proposed system aimed at continuously monitoring live weather conditions, specifically focusing on the Indian region in locally specified areas. Employing a client-server architecture model powered by IoT technology within a Two-tier Architecture framework, the system integrates various sensors for monitoring temperature, humidity, rainfall, atmospheric pressure, and air quality. Data captured by these sensors is transmitted to a NodeMCU controller, utilizing Arduino IDE for data uploading. Acting as a gateway between sensors and the cloud, the serial monitor facilitates data transmission to an IP address linked to ThingSpeak, providing access to weather data via a web server interface. By making the data publicly available, our system enables comprehensive weather monitoring in India, eliminating the need for specific applications or websites. Comparative analysis with standard weather parameters demonstrates the superior performance of our proposed model. The Smart Weather Monitoring System integrates ESP8266-based weather stations with ThingSpeak, offering a robust solution for real-time weather data collection, processing, and visualization. Equipped with sensors to measure key weather parameters, ESP8266 devices wirelessly transmit data to ThingSpeak for further analysis, facilitating access to a comprehensive weather dashboard with real-time information and historical records. This project addresses the need for an intelligent and efficient weather monitoring system across various applications, providing users with access to real-time weather data anywhere.

Keywords: *ThingSpeak, Smart weather monitoring Systems, NodeMCU, Arduino, IoT etc*

1.Introduction:

Monitoring weather conditions and air quality is of paramount importance in India, affecting various sectors such as agriculture, industry, construction, and others. However, its ramifications are most keenly felt in agriculture and industry, which are vital components of India's economy. Agriculture, in particular, contributes significantly to India's GDP. Recently, the concept of smart agriculture, utilizing IoT technology, has garnered considerable attention worldwide. The term "smart" implies optimizing parameters to achieve superior outcomes while minimizing resource usage, such as land, water, and time, and integrating cutting-edge technologies and scientific advancements to boost crop productivity.

Despite advancements, security remains a significant concern in IoT networks, with numerous techniques available but still requiring enhancement. In agriculture, weather plays a pivotal role in various farming phases, especially in regions like Gorakhpur, where rainfall predominates due to its proximity to the hilly terrain of Nepal. This rainfall pattern poses challenges for farmers, impacting farming activities from sowing to harvesting. Accurate weather monitoring, including air quality, becomes indispensable for informed decision-making regarding crop management. India spans a total area of 3,287,263 square kilometers (1,269,219 sq mi). Out of the 160 million 39 million hectares can be irrigated using groundwater wells, with an additional 22 million hectares being irrigable through irrigation canals. This extensive irrigation infrastructure plays a cucial role in supporting agriculture across the country, contributing significantly to India's food security and agricultural productivity.

The primary objective of our system is to provide Indian farmers with timely weather information, including air quality data, to facilitate decision-making processes related to crop cultivation. This paper comprises a literature review in Section II, followed by the development of a weather monitoring system in Section III. Section IV details the hardware components of our system, while Section V presents the real-time analysis of

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, May : 2024

experimental results. Finally, the paper concludes with a summary of findings and suggestions for future research.

2.Literature Survey:

Mary Nsabagwaa, Maximus Byamukamab, Emmanuel Kondelaa, [1] proposed a robust and cost-effective Automatic Weather Station (AWS) to tackle the challenge of weather prediction, especially during extreme events. This AWS, based on wireless sensor networks, aimed at developing three generations of prototypes, with a focus on enhancing non-functional requirements like power consumption and data accuracy. By doing so, the AWS becomes more accessible and affordable, particularly in developing countries like Uganda, where weather observations are scarce due to the high costs associated with conventional weather stations.

Ravi Kishore Kodali and Snehashish Mandal,[2] introduced an IoT-based weather monitoring system that employs various sensors to measure environmental parameters such as humidity, temperature, pressure, rain value, and light intensity. The system is equipped with an alert mechanism via SMS, email, and tweets for predefined parameter thresholds. Using components like NodeMCU 8266 and diverse sensors, this system demonstrates the integration of IoT for real-time weather monitoring.

Ravi Kishore Kodali and Archana Sahu [3] presented a low-cost live weather monitoring system, as utilizes an OLED display and ESP8266-EX microcontroller-based WeMos D1 board. By leveraging minimal hardware requirements, this system provides live weather updates through a Thingspeak website, offering easy implementation and accessibility via the OLED display.

Zi-Qi Huang, Ying-Chih Chen and Chih-Yu Wen, [4] introduced a weather monitoring and prediction system that integrates sensor data from vehicles like buses with deep learning technology. Divided into two stages of sensing weather conditions and training prediction models, this system exhibits reliable performance in real-time weather reporting by combining local information processing with bus-based sensor data.

Kavya Ladi, A V S N Manoj, G V N Deepak, [5] implemented an IoT-based weather monitoring system focused on climate change awareness, utilizing IoT technology and swarm algorithm for enhanced accuracy in data collection and storage. With the aim of raising awareness about climate conditions, this system provides efficient and accurate weather monitoring through cloud-based storage.

P. Susmitha, G. Sowmyabala,[6] designed and implemented a standalone modular weather monitoring system with remote capabilities using embedded systems. Incorporating sensors for various environmental parameters, this system enables real-time weather monitoring and data logging through transmission to a remote interface via LABVIEW.

Tanmay Parashar1, Shobhit Gahlot2, Akash Godbole3, Y.B. Thakare4 [7] discussed a weather monitoring system utilizing Wi-Fi modules for data transmission, employing multiple sensors to monitor environmental parameters. The system's data transmission to a main server via Wi-Fi enables continuous display of real-time weather updates on a website.

Nutant Sabharwal, Rajesh Kumar, Abhishek Thakur, Jitender Sharma, [8] proposed a low-cost ZigBee-based automatic wireless weather station with GUI and web hosting capabilities. Utilizing an Arduino Uno board for data collection and ZigBee wireless link for transmission, this system provides real-time weather updates and data logging accessible via web hosting.

M. Prasanna, M. Iyapparaja, M. Vinothkumar, B Ramamurthy, S.S. Manivannan, [9] introduced an intelligent weathering system leveraging IoT technology and machine learning algorithms for real-time weather monitoring and prediction. By collecting and analysing data in the cloud, this system offers cost-effective and efficient weather monitoring, benefiting industries like agriculture and logistics.

Mircea Popa and Catalin Iapa,[10] presented an embedded weather station with remote wireless control, offering multiple solutions for weather monitoring using various sensor networks. Additionally, featuring an SMS service for remote monitoring and control enhances the accessibility and usability of this system.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, May : 2024

T.R.V. Anandharajan G. Abhishek Hariharan, K.K. Vignajeth, R. Jijendiran4kushmita,[11] proposed a weather monitoring system employing artificial intelligence for weather prediction, aiming to enhance accuracy in forecasting through machine learning algorithms and statistical methods. This system provides high accuracy in predicting weather conditions, catering to industries reliant on precise forecasts.

Yashaswi Rahul, Rimsha Afreen, Divya Kamini,[12] introduced an IoT-based weather monitoring system with real-time accessibility, allowing users to monitor climate conditions remotely. By utilizing IoT technology and diverse sensors, this system offers a cost-effective and efficient solution for weather monitoring, with data visualization on a web page and notifications via a mobile application.

Puja Sharma and Shiva Prakash [13] presented a "Real Time Weather Monitoring System Using IoT" in the Department of Information Technology and Computer Application at Madan Mohan Malaviya University of Technology, Gorakhpur.

3. Development of Weather monitoring System using Multi Sensors

The paper discusses the development of a weather monitoring system using multiple sensors, aiming to continuously observe environmental parameters via Wi-Fi.

Mode 1	When Mode 1, represented by the DHT22 sensor for temperature and pressure, is activated, it captures the temperature value and displays it on the webpage.
Mode 2	When Mode 2, utilizing the BMP180 sensor, is active, it displays the barometric pressure of the environment.
Mode 3	When Mode 3 is active, the Rain sensor module measure and displays the rain of environment.
Mode 4	When Mode 4 is Active, the Air Quality sensor Module senses the harmful gasses and based on sensor value we can find different types of gasses.

Table 1. Multiple modes in weather monitoring System

The system incorporates various sensors to measure different parameters, and it proposes a novel approach utilizing IoT technology. Three sensors are organized into bundles within the system, with each sensor connected to the NodeMCU microcontroller. Data from the sensors is automatically fetched and uploaded when connected to Wi-Fi, displaying on webpages accordingly. The proposed model employs sensors for temperature, pressure, humidity, raindrops (mode1, mode2, and mode3), and an air quality sensor (mode4). Each mode corresponds to a specific sensor type, such as the DHT22 for temperature and humidity (MODE-1), BMP 180 for barometric pressure (MODE-2), raindrop sensor for detecting raindrops (MODE-3), and MQ-135 gas sensor for air quality (MODE-4), capable of detecting harmful gases like Ammonia, Sulphur, Benzene, CO2, and smoke. Despite the availability of multiple sensors for weather monitoring, the proposed system focuses on using only four sensors to ensure reliability and effectiveness. Overall, the proposed model offers an efficient and publicly accessible weather monitoring solution, providing accurate environmental weather condition measurements.

4.Hardware Illustration of the proposed system

Fig 1 represents the architecture diagram. With the help of this architecture, every sensor is connected with node MCU pins. The power supply is given to the node MCU by USB which is connected with pc.

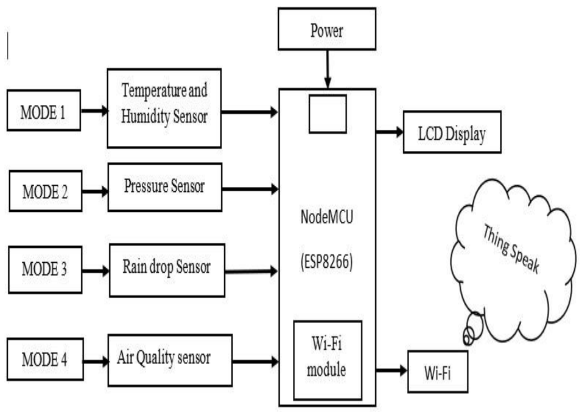


Fig 1.: The proposed model architecture of weather monitoring system.

4.1 Sensors, Gateway, and Data logging

4.1.1 Gateway or Data Collector:

The NodeMCU serves as the gateway in our system, transmitting data to the local network for display on our PC's webpage.

4.1.2 Mode 1 Sensor (Temperature and Humidity Sensor):

The DHT22 sensor operates on 3.3-6V DC, providing digital output via a 1-wire bus. It accurately measures humidity from 0-100%RH and temperature from -40 to 80°C, with ±2%RH humidity accuracy and ±0.5°C temperature accuracy.

4.1.3 Mode 2 Sensor (Barometric Pressure):

The BMP180 sensor is a digital barometric pressure sensor with ultra-low power consumption, operating at 3-5V DC. It senses pressure from 300-1100 hPa and functions between -40 to +85°C.

4.1.4 Mode 3 Sensors (Raindrop Sensor):

The raindrop sensor detects water beyond the humidity sensor's capabilities, acting as a variable resistor with a resistance ranging from 100K Ohm.

4.1.5 Mode 4 Sensor (Air Quality Sensor):

The MQ135 air quality sensor module operates at 5V with a power consumption of around 150mA. It detects various gases like NH_3, NOx, CO_2, Alcohol, Benzene, and Smoke.

5.Circuit Diagram

The circuit diagram of our proposed system is given below. The diagram represents the connection of the sensor and how the connection will be done. The Dht22 sensor, BMP 180 sensor, rain sensor, all are connected with the node MCU pins and the power supply is done by USB cable to connect the hardware to the system. The prototype model is represented in the above images. All the connections should be done in the same manner then will get a proper result.

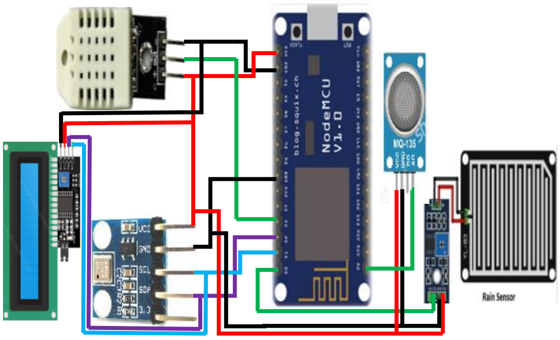


Fig.2. Circuit diagram of the weather monitoring system

Table 2. Pin configuration between node MCU and DHT22

VCC	3V3
DATA	D3
GND	GND

Table 3. Pin Configuration between node MCU and BMP sensor

SDA	D2
SCL	D1
GND	GND
VCC	3V3

Table 4. Pin Configuration between node MCU and Rain sensor

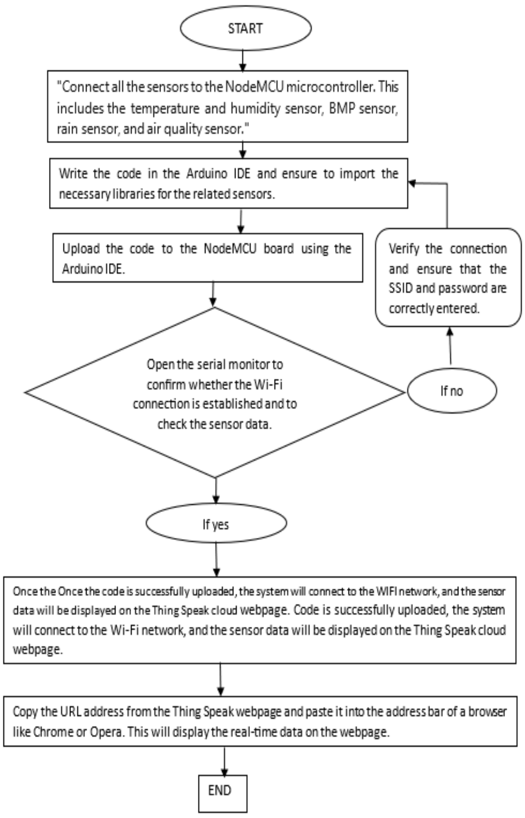
D0	D0
GND	GND
VCC	3V3

Table 5: Pin Configuration between node MCU and Air Quality sensor

A0	A0
GND	GND
VCC	3V3

6.Flow chart of the proposed model

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, May : 2024



The flowchart you sent depicts the steps to establish a connection between various sensors and a NodeMCU microcontroller. The sensors include temperature and humidity, BMP, rain, and air quality sensors. The process involves writing code in Arduino IDE, uploading it to the NodeMCU board, verifying the connection, and opening the serial monitor to confirm Wi-Fi connection and sensor data. Upon successful upload, the system connects to the WIFI network, and the sensor data is displayed on the Thing Speak webpage. The URL from the webpage can then be copied and pasted into a web browser to view the real-time data.

7.Implimentation and Working Process

Setup Thing Speak Account

Thing Speak is an IoT platform that allows you to collect, visualize, and analyse sensor data in real-time. Start by visiting [ThingSpeak.com](https://thingspeak.com/) and signing up for an account if you haven't already.

Upon registration, Thing Speak will provide you with an API key. This key is essential as it authorizes your device to send data to the Thing Speak platform.

Configure the Sensors

DHT22 Sensor: Also known as the AM2302, the DHT22 sensor measures both temperature and humidity. To integrate it into your IoT setup, connect it to your microcontroller or IoT device according to its specifications. The DHT22 typically operates on a 3.3-6V DC power supply and communicates using a digital signal via a 1-wire bus.

BMP180 Sensor: The BMP180 sensor measures barometric pressure and temperature. Connect it to your device in a similar manner to the DHT22. The BMP180 operates at a voltage range of 3 to 5V DC and communicates over the I2C protocol.

Rain Sensor: Rain sensors detect the presence of water on their surface and are used to detect rain events. Depending on the type of rain sensor you have, you may need to calibrate it to ensure accurate readings. Connect it to your device as per the sensor's specifications.

MQ135 Sensor: The MQ135 sensor is designed to detect various harmful gases such as CO_2 and ammonia, making it useful for monitoring air quality. Connect it to your device and ensure it receives adequate power for accurate readings.

Write Code to Read Sensor Data

Using the Arduino IDE or a suitable programming environment, write code to read data from each sensor connected to your microcontroller or IoT device. This code will vary depending on the type of sensor and the specific requirements of your project.

Format Data for Thing Speak

Thing Speak accepts data in a specific format via MQTT (Message Queuing Telemetry Transport). You'll need to format your sensor data into a URL with parameters that can be sent to Things peak's API endpoint. This typically involves constructing a HTTP GET request with the sensor data as query parameters.

Send Data to Thing Speak

Utilize the API key provided by Thing Speak to authenticate device and send sensor data to the Thing Speak platform. Depending on device's capabilities and our preferences, you can use MQTT messages or other suitable methods to transmit the data.

Verify Data on Thing Speak

Once your device is configured to send data to Thing Speak, log in to your Thing Speak account and navigate to the channel where you've configured your data to be sent. Here, you can view your sensor data in real-time and access various visualization and analytics tools provided by Thing Speak to analyse and interpret your data effectively.

Monitor and Maintain

Regularly monitor sensor data on Things peak's webpage, and also consider using additional display methods such as LCD displays or serial monitors to ensure that device is functioning as expected.

It's essential to monitor your setup regularly and make any necessary adjustments to maintain its performance and address any issues that may arise over time. This may involve calibrating sensors, optimizing code, or troubleshooting connectivity problems.

You can access the Thing Speak URL through any web browser, and it will display the current values of temperature, humidity, pressure, rain, and air quality. Here are the results displayed on the webpage.

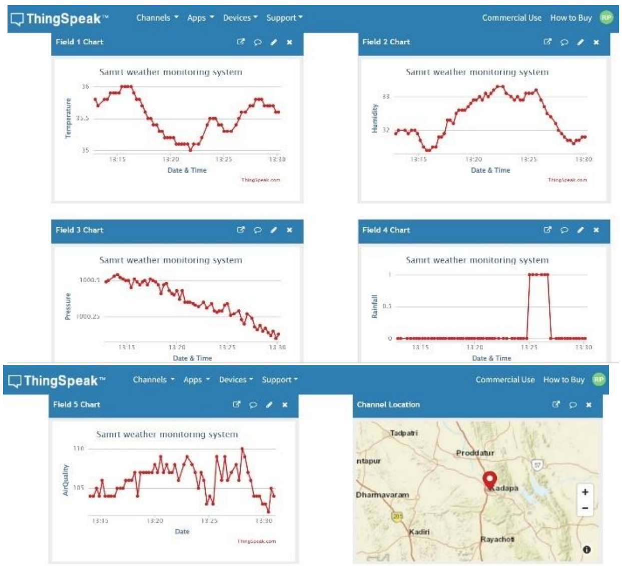


Fig.4. Final Result on Thingspeak webpage

8.Experimental Results and Analysis

The aim of the "Smart Weather Monitoring system using NodeMCU and Thing Speak" is to create a system capable of tracking weather conditions while simultaneously measuring environmental variables via the Internet of Things. A prototype of the weather monitoring system is depicted in Figure 1, which monitors various parameters such as humidity, pressure, rain value, etc. Once the connections are established according to Figure 2, data from the temperature and humidity sensor, pressure sensor, and rain sensor is observed on the web server. The observed data is stored on the web server through MQTT requests, accessible on the webpage.

9.Conclusion

The proposed system aims to monitor weather parameters at minimal cost by employing a client-side architecture model. Utilizing fewer sensors compared to existing models, our approach focuses on cost-effectiveness and affordability, ensuring accessibility for all users. Data collected from multiple sensors is transmitted to a webpage via MQTT request protocol on a web server. Operating in Indian region, the system gathered data from three locations: KSRM College (Kadapa), and Proddatur , Jammalamadugu . Analysing the above data from KSRM College only form with timestamps allows for informed decision-making. This system not only benefits farmers by providing environmental insights but also aids in various other sectors such as industry and transportation. The accuracy of our proposed model aligns closely with real data, enhancing its reliability and utility.

References

[1] Nsabagwaa, M., Byamukamab, M., & Kondelaa, E. (n.d.). Towards a robust and affordable Automatic Weather Station. Retrieved from www.elsevier.com/locate/deveng.

[2] Kodali, R. K., & Mandal, S. (2016). IoT Based Weather Station. 2016 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT).

[3] Kodali, R. K., & Sahu, A. (2016). An IoT based Weather Information Prototype Using WeMos. 2016 2nd International Conference on Contemporary Computing and Informatics (ic3i).

[4] Huang, Z.-Q., Chen, Y.-C., & Wen, C.-Y. (2020). Real-Time Weather Monitoring and Prediction Using City Buses and Machine Learning.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, May : 2024

[5] Ladi, K., Manoj, A. V. S. N., & Deepak, G. V. N. (n.d.). IOT Based Weather Reporting System to Find Dynamic Climatic Parameters. International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS-2017).

[6] Susmitha, P., & Sowmyabala, G. (2014). Design and Implementation of Weather Monitoring and Controlling System. International Journal of Computer Applications (0975 – 8887), Volume 97– No.3.

[7] Parashar, T., Gahlot, S., Godbole, A., & Thakare, Y. B. (2015). Weather Monitoring System Using Wi-Fi. IJSR, ISSN (Online): 2319-7064, Index Copernicus Value: 78.96.

[8] Sabharwal, N., Kumar, R., Thakur, A., & Sharma, J. (2014). A LOW-COST ZIGBEE BASED AUTOMATIC WIRELESS WEATHER STATION WITH GUI AND WEB HOSTING FACILITY.

[9] Prasanna, M., Iyapparaja, M., Vinothkumar, M., Ramamurthy, B., & Manivannan, S. S. (2019). An Intelligent Weather Monitoring System using Internet of Things. International Journal of Recent Technology and Engineering (IJRTE).

[10] Popa, M., & Iapa, C. (2011). Embedded Weather Station with Remote Wireless Control. 19th Telecommunications forum TELFOR 2011 Serbia, Belgrade.

[11] Anandharajan, T. R. V., Abhishek Hariharan, G., Vignajeth, K. K., & Jijendiran, R. (2016). Weather Monitoring Using Artificial Intelligence. 2016 International Conference on Computational Intelligence and Networks.

[12] Rahul, Y., Afreen, R., & Kamini, D. (2018). Smart weather monitoring and real-time alert system using IoT. International Research Journal of Engineering and Technology (IRJET).

[13] Sharma, R., Prakash, S., & Kumar, P. (2020). Methodology, Applications and Challenges of WSN-IoT. IEEE International Conference of Electrical and Electronics Engineering (ICE3—2020).

[14] Verma, G., & Prakash, S. (2020). A Comparative Study Based on Different Energy Saving Mechanisms Based on Green Internet of Things (GIoT). IEEE 8th International Conference on Reliability, Infocom Technology and Optimization (ICRITO-2020)

[15] Joseph, F. J. J. (2019). IoT Based Weather Monitoring System for Effective Analytics. International Journal of Engineering and Advanced Technology (IJEAT).

[16] Kumar, R., & Prakash, S. (2021). Performance & Parametric Analysis of IoT's Motes with Different Network Topologies. International Conference on Electrical and Electronics Engineering.

[17] Verma, G., & Prakash, S. (2020). Emerging Security Threats, Countermeasures, Issues and Future Aspects on Internet of Things (IoT): A Systematic Literature Review. 2nd International Conference on Future Learning Aspects of Mechanical Engineering (FLAME 2020).

[18] Srivastava, S., & Prakash, S. (2020). An Analysis of Various IoT Security Techniques: A Review. IEEE 8th International Conference on Reliability, Infocom Technology and Optimization (ICRITO-2020).

[19] Verma, G., & Prakash, S. (2019). Internet of Things for Healthcare: Research Challenges and Future Prospects. 1st International Conference on Advanced Communication and Computational Technology (ICACCT).

[20] Sharma, R., Prakash, S., & Kumar, P. (2020). Methodology, Applications and Challenges of WSN-IoT. IEEE International Conference of Electrical and Electronics Engineering (ICE3—2020).