GIRIJANANDA CHOWDHURY INSTITUTE OF MANAGEMENT AND TECHNOLOGY

REPORT ON DISSERTATION PHASE II

Automatic Monitoring and Forecast of Weather System

Submitted in the partial fulfilment of requirement for the Degree of Master of Technology
in
DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY, GUWAHATI

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GIRIJANANDA CHOWDHURY INSTITUTE OF MANAGEMENT AND TECHNOLOGY

2022 – 2024

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

<u>CERTIFICATE</u>

*This is to certify that **Tavishi Shaw** student of M.Tech 2nd Year, 4th Semester, has completed the thesis entitled **"Automatic Monitoring and Forecast of Weather System"** during the academic session Jan-June, 2024 under my supervision and guidance.*

I approve the project for submission as required for partial fulfilment of requirement for the Degree of Master of Technology.

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DECLARATION

I hereby declare that this Dissertation Phase II work entitled "AUTOMATIC MONITORING AND FORECAST OF WEATHER SYSTEM" was carried out under the guidance and supervision of Mr. K.N Mohan, Scientist G, Additional General Director of IMD and Mr**.** Abhinandan Kalita**,** Assistant Professor, ECE, GIMT-G. This project is submitted to Department of Electronics and Communication Engineering during the academic year 2023-24. The work is never produced before any authority except Assam Science & Technology University for evaluation.

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ACKNOWLEDGEMENT

I am grateful to Dr. Anindita Bora, Head of the Department (I/C), Electronics & Communication Engineering, GIMT, Guwahati, for her cheerful encouragement and valuable suggestions.

The successful completion of the project has been possible due to the sincere co-operation guidance, inspiration, moral support & timely advice of my guide Mr. K.N Mohan, Scientist-G, Additional Director General of IMD and co-guide Mr. Abhinandan Kalita, Assistant Professor, ECE Dept., GIMT, Guwahati who devoted their utmost co-operation in this project work.

I would also like to thank our teachers and all the members of staff of ECE Dept., i.e., Department of Electronics and Communication Engineering of our college for their helpful efforts.

I express my gratitude to my parents who helped in one way or the other. I am highly obliged that I have received all your support whenever I needed.

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ABSTRACT

A weather station can be described as an instrument or device which provides information of the weather in its neighbouring environment. For example, it can provide readings of temperature, humidity, pressure, wind speed, light etc. The system consists of power supply, a set of sensors, microcontroller to receive input data from sensors, processes them and provides information through display system. A working model of weather monitoring and forecasting system has been designed. Based on the data collected from the working model and previous data collected from various sources, weather forecasting will be the done with the help of machine learning.

The power supply to the system is provided by converting AC mains to desired DC voltage. Various types of weather parameters like temperature, humidity, pressure, wind speed, light is measured by using different sensors. The data collected by these sensors is sent to the microcontroller. The microcontroller analyses the input data and gives output signal as text to be displayed in mobile. The data is processed and forecasted through machine learning algorithm.

The weather monitoring and forecasting system is portable having reliable data and forecasting and will be highly useful for various sectors like aviation, agriculture, shipping, road transport, power and energy, disaster management, defence, tourism, pilgrimage, mountaineering, fishing, urban development, sports, health etc.

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CHAPTER 1

INTRODUCTION

The frequency and severity of extreme weather events have increased over the last few decades making predictability of weather a great challenge. Extreme weather events often cause adverse impacts to lives and property. Thus, accurate and timely receipt of weather data is becoming crucial to improve the skill of weather prediction and to strengthen resilience to the impacts of the adverse weather conditions. For round the clock monitoring of weather, Automatic Weather Station (AWS) needs to be installed. An AWS is defined as a 'Meteorological station at which observations are made and transmitted automatically' [1]. It is a facility that automatically transmits or records observations obtained from measuring instruments. The sensors measure the requisite information and converts them into electrical signals. These electrical signals are further processed and transformed into meteorological data. Four sensors are to be used for normal AWS- wind sensor, temperature-humidity sensor, pressure sensor and rainfall sensor. These sensors are coupled with a Raspberry Pi zero W. The data recorded by the sensors are displayed as well as saved. Weather is the present condition of the atmosphere over a given place and time. It is measured in terms of variables like temperature, humidity, pressure, precipitation, wind and light intensity etc. AWSs are classified as offline stations, which save data on storage devices, and real-time stations, which automatically send observed data at certain times. The data is further stored or transmitted via wired or wireless mode to requisite destination.

In modern times, demand for knowing weather parameters has increased many folds in several sectors including common people. Weather plays very important role in daily life. A low cost system is needed to be developed which can observe different weather parameters, stores them for further research and development works. The system is capable of measuring such parameters automatically i.e. without human intervention.

According to IPCC (Intergovernmental Panel for Climate Change) average temperature of earth's surface has increased upto 1.5 degree Celsius with respect to pre-industrial era [2]. Such change in temperature has led to global warming which has caused numerous environmental issues. This has led to monitoring of weather parameters more precisely. Hence demand for low-cost weather monitoring system is in great demand.

AWS has automated data acquisition system i.e. it records different meteorological parameters, process and transmits [3]. The recorded data are saved and can be used for data analysis and other research and development as well as operational works. The weather monitoring and forecasting system is portable in size having reliable data and forecasting and will be highly useful for various sectors like aviation, agriculture, shipping, road transport, power and energy, disaster management, defence, tourism, pilgrimage, mountaineering, fishing, urban development, sports, health etc.

1.1 Background and Motivation

Weather is the present condition of the atmosphere over a given place and time, measured in terms of variables including precipitation, temperature, wind, light intensity and humidity among others. Weather can change over a short period of time such as hours and days. Study of weather for longer period helps in preparing climatology of a particular place. Weather plays a very important role in day-to-day life of people, farmers including flora and fauna. Weather data is very important in agriculture especially in India where a majority of population is dependent on agriculture. Weather has a major impact on the economic growth of any country. So, it becomes necessary to study weather and issue accurate weather forecast. For this, there is a need to have accurate and timely weather data collection and their transmission. This necessitates robust weather instruments to provide accurate and timely transmission of weather data which can be achieved with increased density of weather station networks. Hence increased precision of readings and a better representation of areas under observation helps in better weather forecast.

An AWS consists of sensors and data logger which automatically collect and transmit weather data. If these AWSs are deployed in a large number in equally spaced area, the reliability and accuracy of weather forecast gets improved. However, the high cost of the available AWS hinders their acquisition in big numbers for many developing countries. Additionally, since most commercial AWS are expensive and, in some cases, the spares are imported, this makes maintenance normally costly. Therefore, there is a need to design affordable AWS and also to get weather forecast of that place using Machine Learning.

1.2 Literature Review

S. Madan, et.al [4] proposes the whole world is plagued by the dynamical clement and their facet, to cut back this facet effects up to some extent there are several techniques and algorithms through which weather is predicted on the ready reference along with respective context of given information from past years example temperature, dew, humidity, air pressure and wind direction. When doing the analysis of existing data from past few years the proposed scheme or techniques is inculcated which have a tendency to conclude that, machine learning paradigm and permits us to research the given set of knowledge and extract the helpful information from the given dataset, thus so as to grasp the unsteady patterns of climatic conditions, a prognosticative model is also persuaded. In this paper, progressive statistical linear regression is explored vector machine techniques of machine learning information sets along and to prefigure the forecast or weather prediction. Under the proposed scheme the tendency to inculcate the augmented algorithmic rule that provides approximate and nearby results to forecast the climate for the next 5 days and at the end results are calculated on the idea of mathematical and statistical decision tree and conditions vide confusion matrix for more appropriate and accurate forecasting using Big Data.

N.Singh, et.al [5] proposes that the activities of many primary sectors depend on the weather for production, eg. farming. The climate is changing at a drastic rate nowadays, which makes the old weather prediction methods less effective and more hectic. To overcome these difficulties, the improved and reliable weather prediction methods are required. These predictions affect a nation's economy and the lives of people. To develop a weather forecasting system that can be used in remote areas is the main motivation of this work. The data analytics and machine learning algorithms, such as random forest classification are used to predict weather conditions. In this paper, a low-cost and portable solution for weather prediction is devised. The prime objective of this work is to develop a low-cost, reliable, and efficient weather forecasting application using the machine learning concept in Python on Raspberry Pi board.

S.Singh et.al [6] proposes three machine learning models for weather prediction namely Support Vector Machine(SVM), Artificial Neural Network(ANN) and a Time Series based Recurrent Neural Network(RNN). It also discussed the steps followed to achieve results. RNN using time series along with a linear SVC and a five-layered neural network is used to predict the weather. The results of these models are analyzed and compared on the basis of Root Mean Squared Error between the predicted and actual values. For weather Forecasting, this paper uses Pandas, NumPy, Keras, Git, Matplotlib, TensorFlow, Anaconda and Google Cloud Services. It is found that Time Series based RNN does the best job of predicting the weather.

J.P Mondol, et.al [7] proposes application of Internet of Things (IoT) in a poultry farm allows a real-time monitoring of the context of the farm through notification to smartphone, predicts the context in advance, advises right decision at the right time that saves poultry lives, minimize the economic loss, and improves the productivity and quality. Monitoring weather of the poultry farm is one of the important issues that involves monitoring the status of the temperature, humidity etc. that has impact on raw materials and quality of food, health condition of the poultry, feeding in time, food management, etc. Considering the fact, to improve the management and to increase the efficiency of the farm, an IoT based weather monitoring system for a poultry farm has been proposed in this article. DHT11 is used to measure the temperature and humidity in the proposed system. The collected data is transmitted to a cloud-based server, stored in a database and compared with threshold values continuously. If the stream of data crosses the threshold values and remains higher for certain duration than the system sends an alert message to smartphone and a signal to a buzzer. To validate, the proposed system has been implemented that sends alert messages to smartphone and signals to a buzzer successfully.

K.Geetha Rani, et.al [8] proposes to predict weather forecasting using a mathematical model. The parameters such as minimum temperature, maximum temperature, relative humidity and pressure are used to predict the temperature and rainfall of a particular region. Predicting a weather of a particular region is a tedious process due to rapid change in the climate and the environment. In this project work, a mathematical model based on time-series data is used to predict weather forecasting of a particular region over a period of time.

A. Mothukuri [9] proposes the system is an advanced solution for monitoring the weather conditions at a particular place and make the information visible anywhere in the world. The technology behind this is Internet of Things (IoT), which is an advanced solution for connecting the things to the internet and to connect the entire world of things in a network. In agriculture zone it will be very difficult to check and monitor the weather parameter through wires and analog devices during some weather hazards. To overcome this problem here the wireless sensors are used to check and monitor the weather parameters. We will interface DHT11 Humidity & Temperature Sensor and FC37 Rain Sensor with Node MCU ESP8266-12E Wifi Module. The system proposed for monitoring weather conditions in a particular place like temperature, humidity, CO Level using sensors, sensors detect changes in environment and send it to the users for making statistical analysis, data collected by this is uploaded in web, so this can be useful to everyone in the world.

N. Nanthini, et.al [10] proposes integration of a two-dimensional control system with information acquisition methods, and builds based on the symbols, a database device used to create the given data. The sensors are the primary attributes to create the device for live weather monitoring. A variety of sensors can be used to measure and maintain temperature and humidity. While the output is presented on the LCD screen, the obtained records can be presented inside as virtual output. The entire system also periodically adjusts the weather conditions at the designated location to monitor and manage the area within the given location. In this way, the Temperature and Humidity can be accurately determined and indicated in a particular area, and the final result can be displayed on the LCD display.

D. Mohapatra, et.al [11] proposes the development and deployment of a cost-effective IoT platform to monitor and archival weather data, namely temperature, humidity, atmospheric pressure and dust particles in a residential area, using open-source technologies. The IoT device sends the data to a remote virtual private server (VPS) over the Internet. A server application runs 24x7 to collect the data and logs it into a database. The necessary steps to set up a VPS server, secure it and install the IoT server application implementing the message queuing telemetry transport protocol are also described. The complete system is verified by real-time implementation using IoT devices, namely NodeMCU ESP 8266 and Raspberry Pi Zero W, along with suitable sensors. The work demonstrates the proof-of-concept feasibility of developing and deploying a scalable weather station from scratch using open-source technologies for faster time to market and the privacy and safety concerns with the end product.

L.Y Heng, et.al [12] proposes help of IoT to integrate all devices, connect them to the Internet and frame an intelligent ecosystem. A smart weather monitoring system detects temperature, humidity, pressure, altitude, dew point, and light level, as well as the existence of water in a specific place. All data is shown on the OLED screen and then displayed on the Ubidots website and app. If the vicinity is dark, LED will turn on automatically, and an alert sound will be generated if water is detected. The system also sends SMS based on certain conditions. Authors have used various hardware devices, including Node32 Lite, BMP280, DHT22, MH-RD, OLED, LED, LDR, piezo buzzer, etc., in providing the proof of concept.

M.H Anik, et.al [13] proposes a modern approach used for evaluating climate conditions at a specific location and making data visible throughout a network range. The technology underlying this is the Internet of Things (IoT), which is a cutting-edge and cost-effective method used for connecting things to the internet and linking the Internet of Things in a network. The system uses sensors to monitor and adjust environmental parameters such as temperature, relative humidity, barometric pressure, and rain level, and then sends the information to a web page, where it is plotted. Data from the deployed system can be accessed through the internet by using a smartphone, laptop, computer or tablet. Overall, the proposed system has produced good results; the predicted outcomes can be accomplished with a high degree of accuracy, while adhering to the system's design with the aim of becoming low-cost and user-friendly.

Shashidhara K S, et.al [14] proposes fundamental components of a weather monitoring system with the help of sensors that measure meteorological variables like temperature, humidity, rainfall, etc. IoT implementation extracts, stores and uploads the relevant data to the cloud. A smart community would be created if the suggested solution is applied in a collection of smart homes. When necessary, the occupants can check the output of the sensors that are installed in their own residences.

S.Banara, et.al [15] proposes to diversify weather monitoring system frameworks with the internet of things in the long term and to improve the results with knowledge and comprehension from the rapid development of digital learning research, such as low-cost sensors and renewable energy sources, under which two dominant systems interact against one another and, one to create more precise information and another to forecast the condition.

S.K Jayasingh, et.al [16] proposes different machine learning models that will make use of the historical data to train the models and then the model will be used to predict the weather whose accuracy is better than the traditional models. The evaluation of the models on the basis of accuracy shows that the models outperform and can be used as state-of-art technique to predict the weather in smarter way in less time. The weather events are estimated using a machine learning model that takes into account the different weather parameters. In this paper, different machine learning models are presented which can be used for prediction of weather with much simpler and easier way than the physical models. The accuracy evaluation of the models shows that the machine learning models perform better than the traditional methods of weather forecasting.

Vinoth Kumar K, et.al [17] proposes in-depth analysis of IoT based Solar Power and Weather Monitoring System as all know Renewable energy sources are proven to be one of the most reliable and accepted worldwide as source of energy which can fulfil needs of human without any wastage of resource. Solar power is the one of the emerging and cleanest sources of energy which is present in today's modern world, up to this has zero carbon emission. To use this energy, one should know all about it and its application with respect to the subject so that one can harness this solar power generation. The IoT based Solar Power and Weather Monitoring System has been proposed to collect, evaluate and analyze the solar energy parameters along with weather monitoring so that one can predict the performance and ensure accurate use of solar power and its surrounding parameters. The main advantage of the system is that it helps in monitoring of both solar power and weather parameters around it. This will lead to optimal performance for better understanding of solar Power. The main target of this IoT based Solar Power and Weather Monitoring System is to offer an understanding on monitoring of solar power and weather parameters, this monitoring will be useful for data analysis of a particular region where this system will be installed.

Narendra Kumar, et.al [18] proposes to monitor and review the current weather conditions to keep people up to date with the latest information and allow for the timely implementation of preventative measures if a disaster is anticipated. Arduino is an open-source electronic device creation platform that is based on the amalgamation of hardware and software components that can be freely and flexibly modified to fulfil the needs of the project. The weather forecasting device is used for monitoring weather conditions, more precisely the temperature, humidity, and moisture content of the soil, from which the user gets real-time weather conditions of the place to take necessary actions accordingly, like watering plants, acting against increased LPG or certain gas content in the atmosphere, and many more. After training and testing of results, it follows that the accuracy of weather monitoring does increase and is a better option for increasing datasets. Furthermore, the low cost of the device makes it easily available to farmers.

1.3 Problem Statement

Weather is the conditions of the atmosphere for a particular place at a short period of time. Weather may change every hour, every day. From the beginning of human civilization, man has been very much dependent upon weather and climate. Weather plays major role in many sectors like aviation, agriculture, shipping, road transport, power and energy, disaster management, defence, tourism, pilgrimage, mountaineering, fishing, urban development, sports, health etc. Hence, it is necessary to record weather parameters.

A good network of surface weather observation is needed for homogenous weather monitoring and weather forecasting. Setting up an automatic weather station is a costly affair. It is very difficult to install a good number of such observatories by a country who is economically not so sound and also its area is very big. So, a cost effect automatic weather monitoring and forecasting system is needed. It is also necessary that the system should not only be cost effective but also the measurements are reliable.

1. In the first phase of the project, a portable weather monitoring system was made which is portable and easy to carry for installation. Also, its data reliability remains good. Wind speed, temperature, TBRG, LDR sensor, humidity and pressure are

integrated with weather monitoring system with the help of IoT. Wind speed is necessary to know not only about present weather conditions but also about the weather likely to be observed after some time. Measurement of temperature is helpful in knowing prevailing temperature and also maximum and minimum temperature of a particular day. Humidity measures content of water vapour in the atmosphere. Areas of low pressure can be stormy and areas of high pressure will be calm and sunny. Light sensor is included for capturing light intensity levels helping to analyse daylight conditions. Rain sensor will record occurrence of rain. The observed data will be displayed on mobile/ laptop.

2. In the second phase, data logging functionality is implemented to capture and store sensor data over time. Code is developed to analyse the collected data, identify patterns and begin basic weather predictions. Mechanism is developed to collect data. After that the data is tested, stored and analysed. Advanced weather forecasting algorithms are implemented using machine learning.

CHAPTER 2

THEORETICAL CONSIDERATIONS

Weather variables such as wind speed, temperature, humidity, pressure, light intensity and rainfall are important factors in determining the course of a wide range of events. For example, agriculture has always been highly dependent on weather and weather forecasts, both for its control on the quality and quantity of a harvest and its effect on the farmer's ability to work on the land or to graze his stock. Water resources generally depend critically not just upon rainfall, but also other weather phenomenon that together drive plant growth, photosynthesis and evaporation. Just as pollen and seed dispersal in the atmosphere are driven almost entirely by the weather, so too is the direction and distance of travel of atmospheric pollution. Weather monitoring is also important not just in defining present climate, but also for detecting climate change and providing the data to input into models which enable us to predict future changes in our environment. Because of the wide variety of uses for the information, there are a large number of environmental variables which are of interest to different groups of people. These include solar radiation, wind speed, wind direction, barometric pressure, air temperature, humidity and radiation. The demand for these data, usually on an hourly or more frequent timescale, has increasingly been met by the development and widespread deployment of automatic weather stations (AWS's) over the past 30 years or so. AWS is composed of following: sensor, transmitter, processing device, data transmitting device, power supply. The transmitter converts weather parameters sensed by sensors into electric signal then, processing device will process these electrical signals and convert them into corresponding meteorological elements [19].

The automatic weather station used by research labs are highly sophisticated for monitoring & logging of intrinsic weather conditions like temperature, barometric pressure, wind direction, wind speed, wind chill and other optional parameters according to the requirements of the users. These weather stations are very costly.

The impact of meteorological issues on people's lives can not be underestimated. It is closely related to social production and economic development. Causalities, property losses, and resource destruction caused by meteorological disasters have occurred from time to time [20]. That is why constant monitoring and forecast of weather parameters are very important.

Weather parameters are now a days used by several users including common people, so low-cost weather monitoring system in required. To make it low cost, portable, user friendly and remotely accessible weather monitoring and forecast system is developed. It involves the continuous collection, analysis and interpretation of meteorological data using automated systems and technologies. The theoretical contributions in this field are pivotal for advancing our understanding of weather patterns, improving forecasting accuracy and aiding various industries and sectors that rely on weather-related information. Here are some key theoretical contributions:

- Sensor Technologies and Data Collection: Theoretical advancements focus on designing and deploying sensors capable of accurately measuring various meteorological parameters such as temperature, humidity, pressure, wind speed, light intensity and precipitation. Research delves into sensor calibration, reliability, and deployment strategies to ensure the collection of high-quality data.
- Data Processing and Quality Control: Theoretical frameworks address methods to process vast amounts of data obtained from weather sensors. This involves data filtering, quality control algorithms, and error detection techniques to ensure the accuracy and reliability of the collected information.
- Real-time Monitoring: Theoretical frameworks in developing real-time monitoring systems, the collection of real time data from sensors, and graph plotting and saving of data for future analysis.
- Visualization and User Interface Design: Theoretical advancements in visualization techniques and user interface design aim to present complex weather data in an understandable and accessible manner. This contributes to improving the interpretation of weather information by meteorologists, policymakers and general public.

In essence, theoretical contributions in automatic weather monitoring systems revolve around advancements in sensor technologies, data processing, modelling techniques, and their applications. These developments play a crucial role in enhancing weather forecasts, improving disaster management and aiding various industries dependent on weather-related information.

CHAPTER 3

CONTRIBUTION

Six parameters are measured i.e., temperature, humidity, pressure, wind speed, rain, light intensity. All the measured data are collected and saved. Previous data were collected from the organisation. Based on previous data and measured data weather forecasting is done using machine learning algorithms.

All the 6 parameters from different sensors are measured and recorded continuously every minute. Raspberry Pi records data and save them in memory card. From mobile, Wi-Fi hotspot is given, so laptop and raspberry pi both are connected with same hotspot. In laptop from Real VNC Viewer IP address of hotspot is typed, so that Raspberry Pi Operating system is opened. It is like other OS like Windows. Thonny is installed in Raspberry Pi OS, so the program is opened and run. An IP address is generated after program is run. This IP address can be opened in any browser with laptop as well as mobile which is a local web host, but that device should be connected with same Wi-Fi hotspot. In the webpage all the live data of parameters are displayed along with real-time graph. Live data and time are updated. In the right side of the webpage a calendar is there where previous data can be downloaded in .csv file. This daily data is recorded and saved continuously for future purpose. Weather prediction is displayed at the bottom of the web page along with mean square error.

3.1 Block Diagram

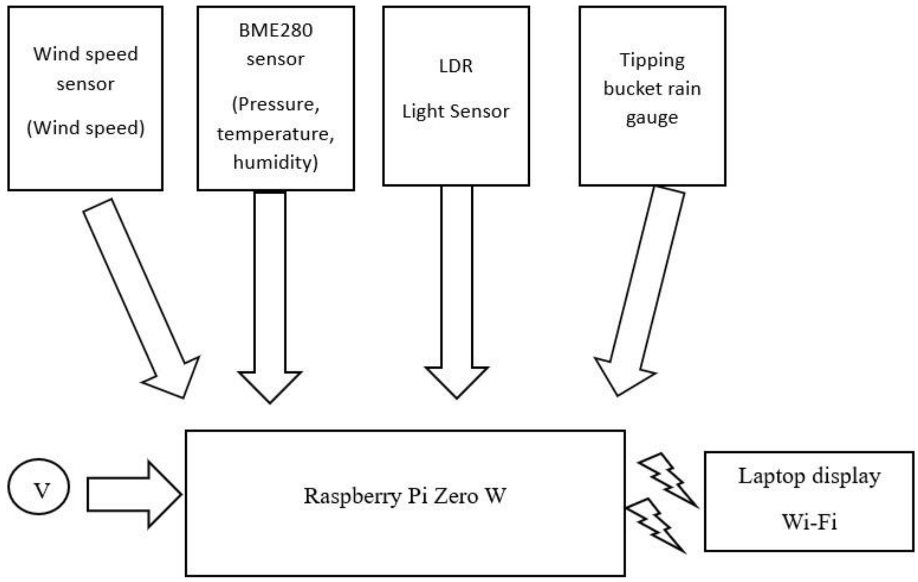


Fig. 3.1 Block diagram of Automatic Weather Station

3.1.1 Explanation of Block Diagram

Power supply is given to the Raspberry Pi. Wind speed sensor (for measuring wind speed), BME280 sensor (for measuring temperature, pressure and humidity), LDR sensor (for measuring light intensity), TBRG (for measuring rain) are interfaced with Raspberry Pi. A user-friendly html page is developed to show the measured values which can be connected through Wi-Fi.

3.2 Circuit Diagram

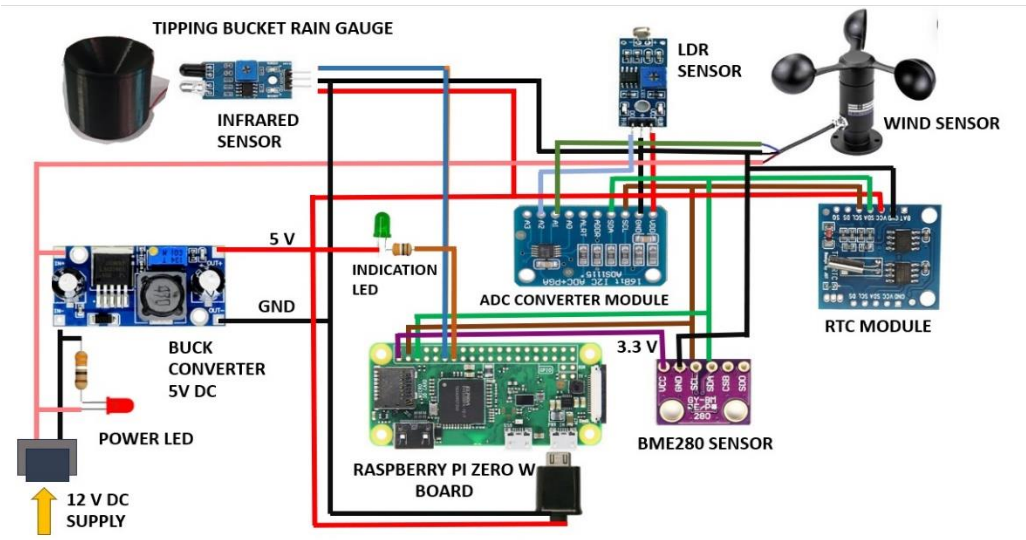


Fig. 3.2 Circuit Diagram of Automatic Weather Station

3.2.1 Explanation of circuit diagram

12V DC power supply is given to the circuit, one red LED is connected along with a resistor, to indicate that device is in ON condition. 12V DC supply is connected to the wind sensor. One buck converter is attached with 12V DC to convert voltage to 5V because other sensors like BME280, TBRG, Raspberry Pi works in 5V. So it functions as step down voltage. TBRG, LDR sensor and wind sensor are connected with ADC module, because these sensors give analog output, so module will convert it to digital output and give it to the Raspberry Pi. BME280 works in 3.3 V and gives digital output so it connected directly with Raspberry Pi. Also, one RTC (Real Time Clock) module is connected for giving time update to Raspberry Pi, if device is off for sometime when it is on again then RTC module will update latest time. SD card is attached with Raspberry Pi for data storage.

In the prediction part random forest algorithm has been used. Random Forest is a machine learning algorithm that uses an ensemble of decision trees to make predictions. The algorithm is used create a large number of decision trees, each of which is trained on a different subset of the data. The predictions of these individual trees are then combined to produce a final prediction. Random Forest is a flexible algorithm that can be used for both classification and regression tasks. It is used because Random Forest tends to provide high prediction accuracy compared to many other algorithms. Weather data contains noise due to environmental disturbances, can be eliminated by algorithm. Weather is non-linear and complex which can be managed by this algorithm. Large dataset is handled and vast amount of weather data is suitably processed. Here training set is taken as 80%, test set as 20% and random state is taken as 42.

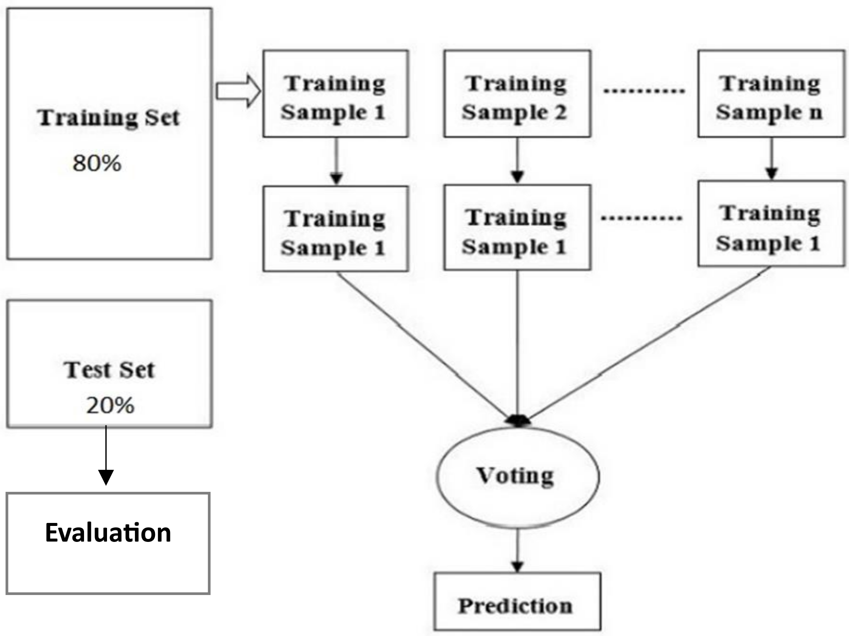


Fig. 3.3 Random Forest Algorithm Flowchart

3.3 Flowchart

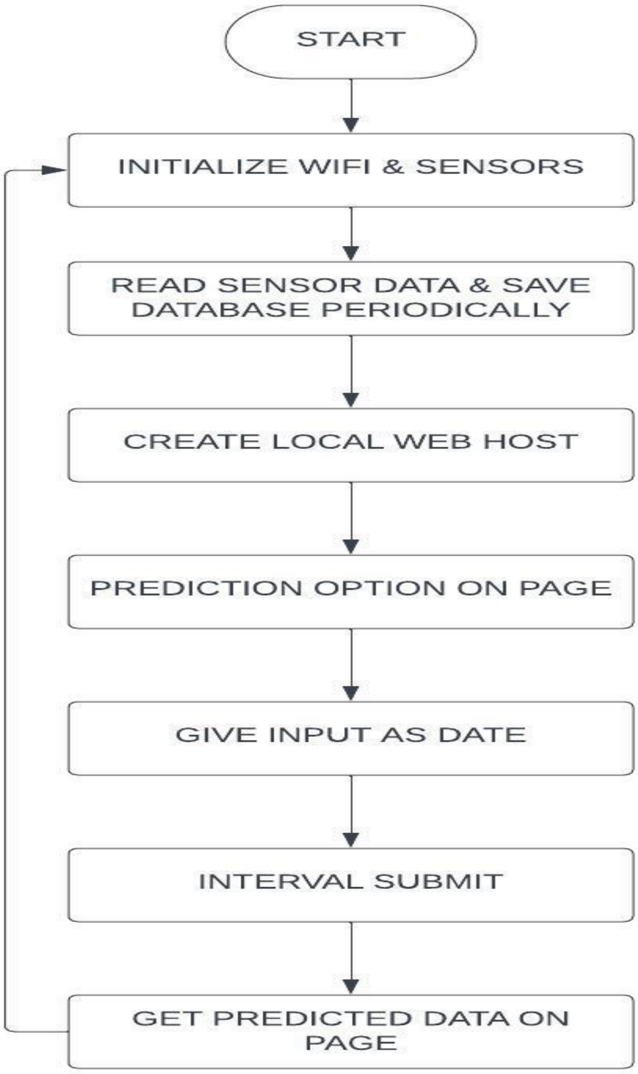


Figure 3.4 - Flowchart

3.3.1 Explanation of flowchart

Initially the circuit is started, then Wi-Fi and all the sensors are initiated. All sensors read data and save it to memory periodically. A local web host is created where all parameters are displayed. This system runs continuously till it reads next set of data. The data is recorded and saved every minute. This runs continuously till the circuit is off.

3.4 Hardware Requirement-

3.4.1 Raspberry Pi Zero W- The Raspberry Pi Zero W is largely reduced size of only 65mm long by 30mm wide and at a very economical price. With the addition of wireless LAN and Bluetooth, the Raspberry Pi Zero W is ideal for making embedded Internet of Things (IoT) projects. The Pi Zero W has been designed to be as flexible and compact as possible with mini connectors and an unpopulated 40-pin GPIO, allowing to use only what the project requires. At the heart of the Raspberry Pi Zero W is a 1GHz BCM2835 single-core processor with 512MB RAM. Quite frankly, this Pi is about four times faster than the original Raspberry Pi and is only a fraction of the cost of the current RPi3.

Figure 3.5- Raspberry Pi Zero W

3.4.2 BME280 Sensor- The BME280 is a humidity, temperature and pressure sensor especially developed for mobile applications and wearables where size and low power consumption are key design parameters. The unit combines high linearity and high accuracy sensors and is perfectly feasible for low current consumption, long-term stability and high Electromagnetic compatibility robustness. The humidity, temperature, pressure sensor offers an extremely fast response time and therefore supports performance requirements for emerging applications such as context awareness and high accuracy over a wide temperature range.

Figure 3.6 – BME280 Sensor

3.4.3 LDR Sensor- LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light. It works on the principle of photoconductivity whenever the light falls on its photoconductive material, it absorbs its energy and the electrons of that photoconductive material in the valence band get excited and go to the conduction band and thus increasing the conductivity as per the increase in light intensity. Also, the energy in incident light should be greater than the bandgap gap energy so that the electrons from the valence band got excited and go to the conduction band. The LDR has the highest resistance in dark around 1012 Ohm and this resistance decreases with the increase in Light.

Figure 3.7 – LDR Sensor

3.4.4 Wind sensor: The three Cups type Wind Speed Sensor Voltage Type(0-5V) Anemometer Kit is an instrument that can measure the wind speed. It is composed of shell, the wind cup, and the circuit module. Photovoltaic modules, industrial microcomputer processor, the current generator, electric current and so on are integrated into the internal drive. It is used to measure wind speed.

Figure 3.8 – Wind sensor

3.4.5 Tipping Bucket Rain Gauge- A tipping bucket rain gauge is a type of instrument used to measure precipitation. It consists of a funnel that collects rainwater and channels it into a small seesaw-like bucket mechanism. The bucket is balanced, so when a certain amount of water collects in it (0.17 millimetres), it tips over. Each tip of the bucket signals a certain amount of precipitation, and these tips are counted electronically. This data can then be used to determine the amount of rainfall over a specific period of time. Tipping bucket rain gauges are commonly used in meteorological and hydrological applications due to their reliability and accuracy. Normal TBRG is very big in size and costly, to make it cost efficient and portable sensor is made by 3D printer.

Figure 3.9 – Tipping Bucket Rain Gauge

3.4.6 ADS1115 ADC Module: This is a 16 Bit I2C 4 Channel ADC Converter Module. This module is based on ADS1115 Chip from TI. It is a precision, low-power, 16-bit, I2C compatible, analog-to-digital converters (ADCs). This device incorporates a low-drift voltage reference and an oscillator. The ADS1115 chip also incorporate a programmable gain amplifier (PGA) and a digital comparator. These features, along with a wide operating supply range, make this module well suited for power- and space-constrained, sensor measurement applications. This is an Analog to Digital Converter Module. It has 4 channel ADC, it can convert 4 analog signals to digital signal. It has I2C communication interface which is used to connect with any MCU.

Figure 3.10 – ADS1115 ADC Module

3.4.7 RTC (Real Time Clock) Module: A real time clock, or RTC, is a digital clock with a primary function to keep accurate track of time even when a power supply is turned off or a device is placed in low power mode. RTC’s are comprised of a controller, oscillator and an embedded quartz crystal resonator.

Figure 3.11 – RTC Module

3.4.8 Buck converter: Buck Converter is a type of chopper circuit that is designed to perform step-down conversion of the applied dc input signal. In case of buck converters, the fixed dc input signal is changed into another dc signal at the output which is of lower value. This means it is designed to produce a dc signal as its output that possesses a lower magnitude than the applied input.

Figure 3.12 – Buck converter

3.4.9 1N4007 Diodes: The 1N4007 is a rectifier diode that converts alternating current to direct current. It's a high-current diode that can handle large amounts of current. It is commonly used in power supply circuits.

Figure 3.13 – 1N4007 Diode

3.4.10 Jumper Wires: Jumper wires are flexible wires with connectors on each end, used to establish electrical connections between components. They are crucial for connecting various components on a breadboard or directly to the Raspberry pi and sensors.

Figure 3.14 - Jumper wires

3.4.11 Light emitting diode: A red colour LED is used in the project, to indicate ON status of the project. Green LED is used to indicate that program is running and blue LED indicates the solar power.

Figure 3.15 – Light emitting diode

3.4.12 Resistor: Here resistor is used to limit current.

Figure 3.16 – Resistor

3.4.13 Relay: A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Figure 3.17- Relay

3.4.14 PCB Board: A printed circuit board (PCB) is a flat, thin board made of non-conductive material that supports and electrically connects various electronic components using conductive pathways, or traces, etched from copper sheets laminated onto a non-conductive substrate. PCBs are integral to most electronic devices, providing a platform for mounting and interconnecting components such as resistors, capacitors, transistors, and integrated circuits.

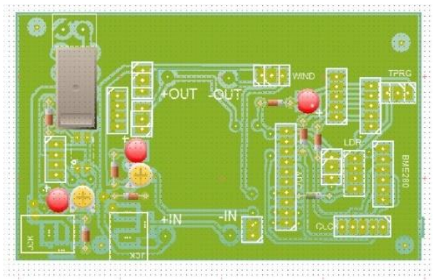


Figure 3.18 – PCB Board

3.5 Software Requirement-

3.5.1 Raspberry Pi OS- Raspberry Pi OS (formerly Raspbian) is a Unix-like operating system based on the Debian Linux distribution for the Raspberry Pi family of compact single-board computers. One can use Raspberry Pi to construct a typical desktop personal computer. The hardware includes Raspberry Pi, a micro-SD card with an operating system installed, a constant power source, and an output display device like an old monitor or television. It is also essential to have a USB mouse and keyboard.

3.5.2 Real VNC Viewer- VNC stands for Virtual Network Computing. It is a cross-platform screen sharing system that was created to remotely control another computer. This means that a computer's screen, keyboard, and mouse can be used from a distance by a remote user from a secondary device as though they were sitting right in front of it. VNC works on a client/server model. A server component is installed on the remote computer (the one you want to control), and a VNC viewer, or client, is installed on the device one wants to control from. This can include another computer, a tablet, or a mobile phone. When the server and viewer are connected, the server transmits a copy of the remote computer's screen to the viewer. Not only can the remote user see everything on the remote computer's screen, but the program also allows for keyboard and mouse commands to work on the remote computer from afar, so the connected user has full control. In this project an IP address is generated after connecting Wi-Fi hotspot to Raspberry Pi and laptop, this IP address needs to be typed in Real VNC Viewer to open Raspberry Pi OS.

3.5.3 Thonny IDE - Thonny is a free and open-source integrated development environment for Python that is designed for beginners. It was created by Aivar Annamaa, an Estonian programmer. It supports different ways of stepping through code, step-by-step expression evaluation, detailed visualization of the call stack and a mode for explaining the concepts of references and heap. The program works on Windows, macOS and Linux. It is available as a binary bundle including the recent Python interpreter or pip-installable package. It can be installed via the operating-system package manager on Debian, Raspberry Pi, Ubuntu, and Fedora.

3.5.4 Python- Python is a high-level, general-purpose programming language. Its design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly procedural), object-oriented, and functional programming. It is often described as a "batteries included" language due to its comprehensive standard library. Python is used in a wide variety of domains, including data science, machine learning, web development, and scientific computing. It is one of the most popular programming languages in the world, and its popularity is only increasing.

3.5.5 HTML- HTML stands for Hyper Text Markup Language. It is the standard markup language for creating Web pages. It describes the structure of a Web page. It consists of a series of elements. Its elements tell the browser how to display the content. In this project HTML code is written in Thonny IDE so a local server is created for a webpage to display and download data.

3.5.6 CSS- CSS stands for Cascading Style Sheets. It describes how HTML elements are to be displayed on screen, paper, or in other media. It saves a lot of work. It can control the layout of multiple web pages all at once. External stylesheets are stored in CSS files.

CHAPTER 4

RESULTS AND DISCUSSION

Automatic Monitoring and forecast of Weather System is developed which measures temperature, humidity, pressure, wind speed, rain and light intensity. All the sensors are interfaced with Raspberry Pi Zero W. The Raspberry Pi is connected through Wi-Fi via Thonny software and all the continuous measured data as well as forecast are displayed on the webpage. The programming is done in python language. This circuit is user friendly.

The Automatic Weather Monitoring and Forecast System functions as follows:

- It collects data from the BME280 sensor for temperature, humidity and pressure.
- It reads the light level using the LDR sensor.
- Wind speed is measured by wind speed sensor.
- Rain is measured by TBRG.
- The data is displayed on webpage with graphical representation.
- The recorded data is saved in .csv file.
- Predicted data is displayed on webpage using machine learning of past data.
- The system also displayed Mean Square Error (MSE).

4.1 Comparison of Data

Various meteorological data have been recorded by the sensors continuously and predicted weather parameters have been obtained. The actual and predicted data have been represented graphically. The following graphs represent 24 hours data recorded from 22nd April 2024 to 7th June 2024 from 00 hrs IST on hourly basis.

Table 1: Predicted and actual data (22-04-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(	Pressure (
1	22-04-2024	00:00:00	26	24	85	85	3	6	0	0	14	10	996	996
2	22-04-2024	01:00:00	25	25	92	90	3	6	0	0	12	10	996	995
3	22-04-2024	02:00:00	25	26	84	86	4	8	0	0	16	15	996	996
4	22-04-2024	03:00:00	25	26	84	87	5	10	0	0	14	16	997	997
5	22-04-2024	04:00:00	24	25	92	95	12	15	0	0	12	11	997	999
6	22-04-2024	05:00:00	24	25	92	94	20	25	0	0	12	12	998	998
7	22-04-2024	06:00:00	25	25	92	92	26	30	0	0	18	20	999	999
8	22-04-2024	07:00:00	26	27	85	88	43	47	0	0	12	10	999	1001
9	22-04-2024	08:00:00	28	30	78	80	67	70	0	0	14	9	1000	1000
10	22-04-2024	09:00:00	29	30	72	70	73	75	0	0	14	12	1000	1002
11	22-04-2024	10:00:00	31	33	61	59	79	85	0	0	14	12	999	999
12	22-04-2024	11:00:00	32	33	51	50	86	88	0	0	20	17	999	999
13	22-04-2024	12:00:00	32	33	51	50	91	89	0	0	18	15	998	998
14	22-04-2024	13:00:00	33	33	47	48	90	90	0	0	14	15	997	997
15	22-04-2024	14:00:00	33	34	47	48	86	84	0	0	12	11	996	996
16	22-04-2024	15:00:00	33	34	47	47	78	75	0	0	6	10	996	994
17	22-04-2024	16:00:00	33	34	47	46	57	54	0	0	14	16	996	996
18	22-04-2024	17:00:00	32	32	51	50	45	43	0	0	12	10	996	995
19	22-04-2024	18:00:00	30	29	67	66	22	20	0	0	10	8	997	997
20	22-04-2024	19:00:00	29	27	66	66	11	15	0	0	8	4	997	998
21	22-04-2024	20:00:00	29	28	72	71	6	10	0	0	4	3	998	998
22	22-04-2024	21:00:00	27	26	85	82	5	9	0	0	6	5	999	1000
23	22-04-2024	22:00:00	26	25	85	86	4	8	0	0	6	7	999	1001
24	22-04-2024	23:00:00	26	26	78	80	3	8	0	0	8	6	998	1000
25	22-04-2024	24:00:00	25	25	84	86	3	7	0	0	8	4	998	1000

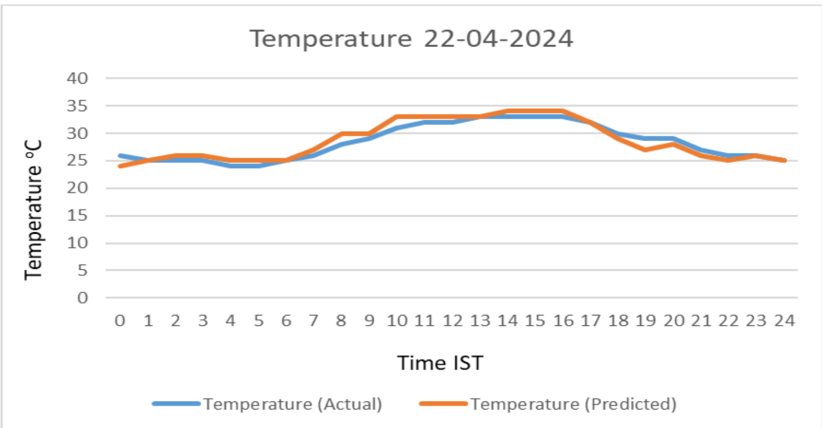


Fig. 4.1 Actual and Predicted Temperature

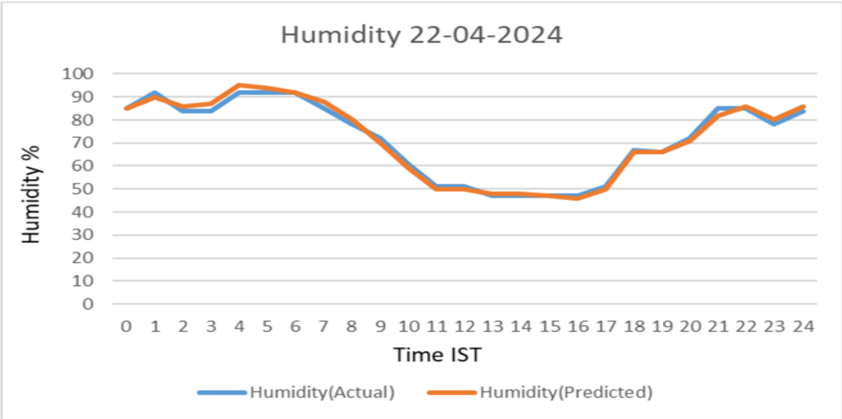


Fig. 4.2 Actual and Predicted Humidity

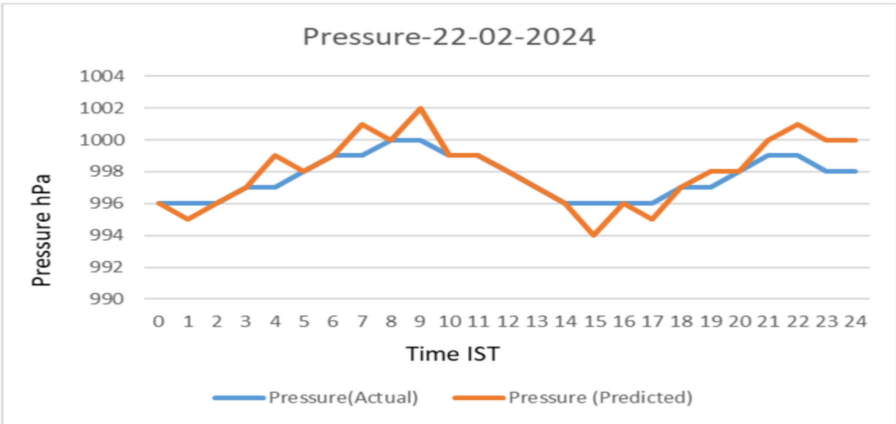


Fig. 4.3 Actual and Predicted Pressure

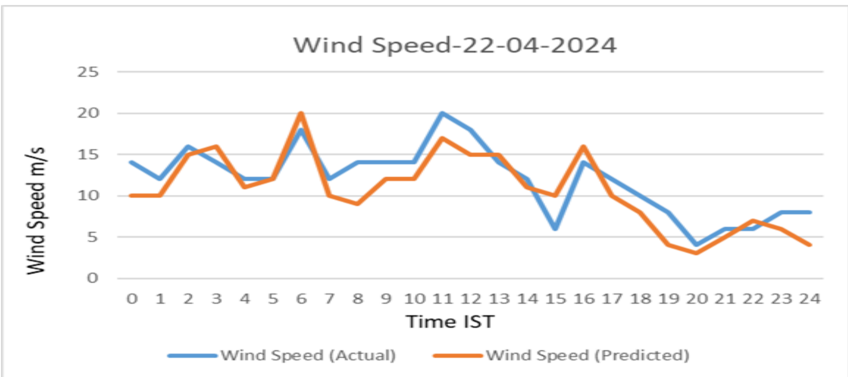


Fig 4.4 Actual and Predicted Wind Speed

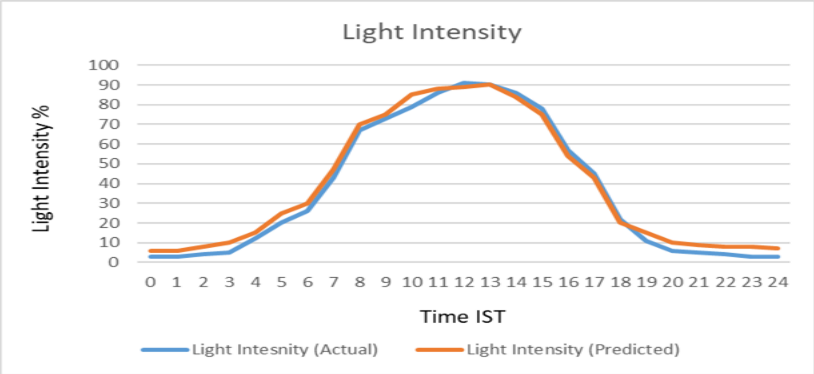


Fig. 4.5 Actual and Predicted Light Intensity

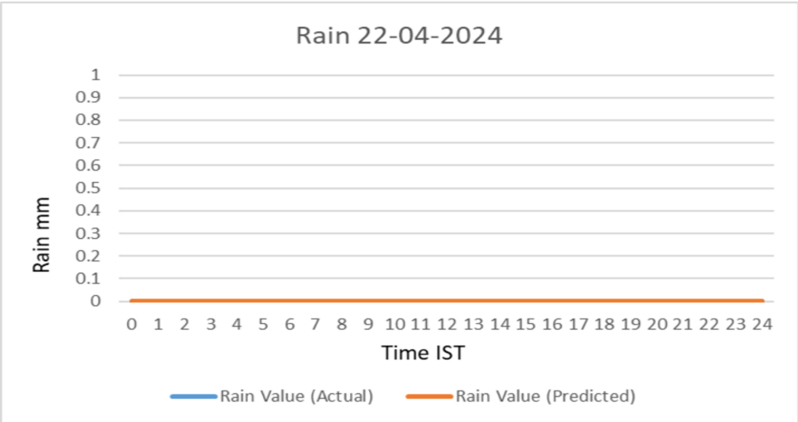


Fig. 4.6 Actual and Predicted Rain

Table 2: Predicted and actual data (23-04-2024)

S.No	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(	Pressure (
1	23-04-2024	00:00:00	25	24	84	86	0	0	0	0	8	10	998	998
2	23-04-2024	01:00:00	25	25	84	90	0	0	0	0	10	10	997	997
3	23-04-2024	02:00:00	24	26	92	89	0	0	0	0	6	2	997	998
4	23-04-2024	03:00:00	24	26	84	87	0	1	0	0	2	2	997	997
5	23-04-2024	04:00:00	23	25	92	95	541	500	0	0	0	3	997	997
6	23-04-2024	05:00:00	23	25	92	94	845	837	0	0	0	3	998	998
7	23-04-2024	06:00:00	24	25	92	90	1021	999	0	0	6	4	999	1000
8	23-04-2024	07:00:00	25	27	92	89	1226	1101	0	0	8	8	999	1001
9	23-04-2024	08:00:00	26	24	78	80	1330	1308	0	0	8	7	999	999
10	23-04-2024	09:00:00	26	25	85	83	1380	1350	0	0	8	7	999	998
11	23-04-2024	10:00:00	28	30	72	70	1356	1380	0	0	6	4	998	997
12	23-04-2024	11:00:00	29	31	48	45	1366	1360	0	0	10	9	998	998
13	23-04-2024	12:00:00	32	33	46	48	1342	1350	0	0	8	11	997	997
14	23-04-2024	13:00:00	32	35	46	50	1287	1299	0	0	6	9	996	996
15	23-04-2024	14:00:00	32	34	41	42	1204	1210	0	0	6	7	996	996
16	23-04-2024	15:00:00	33	36	38	38	1033	1101	0	0	6	8	995	994
17	23-04-2024	16:00:00	33	33	42	32	932	950	0	0	6	10	995	993
18	23-04-2024	17:00:00	32	34	38	37	490	457	0	0	6	5	995	995
19	23-04-2024	18:00:00	31	29	50	51	0	0	0	0	0	2	995	992
20	23-04-2024	19:00:00	29	30	66	68	0	0	0	0	0	1	995	995
21	23-04-2024	20:00:00	28	29	72	75	0	0	0	0	0	1	996	998
22	23-04-2024	21:00:00	27	26	71	76	0	0	0	0	8	5	996	996
23	23-04-2024	22:00:00	27	26	77	78	0	0	0	0	0	2	996	996
24	23-04-2024	23:00:00	26	25	84	87	0	0	0	0	0	4	996	995
25	23-04-2024	24:00:00	25	24	92	89	0	0	0	0	4	4	995	995

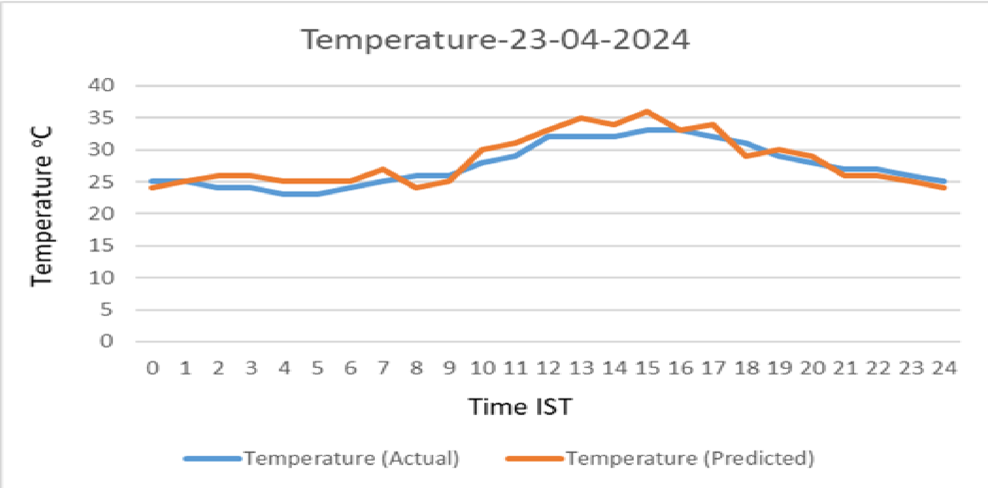


Fig. 4.7 Actual and Predicted Temperature

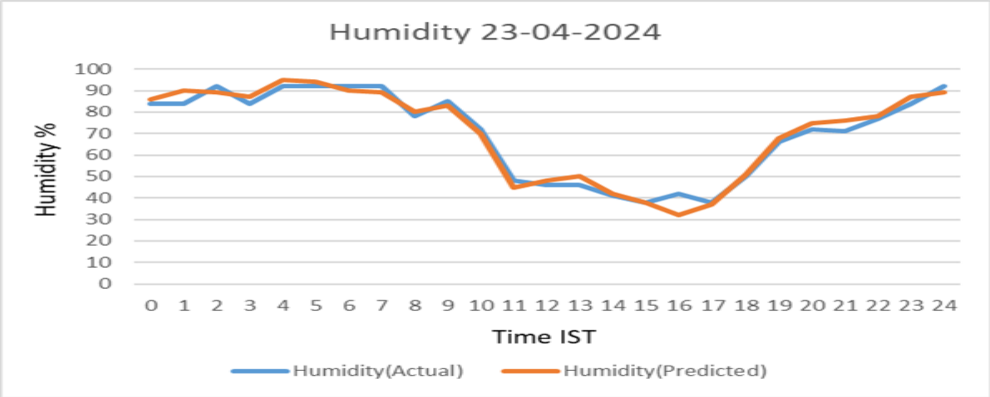


Fig. 4.8 Actual and Predicted Humidity

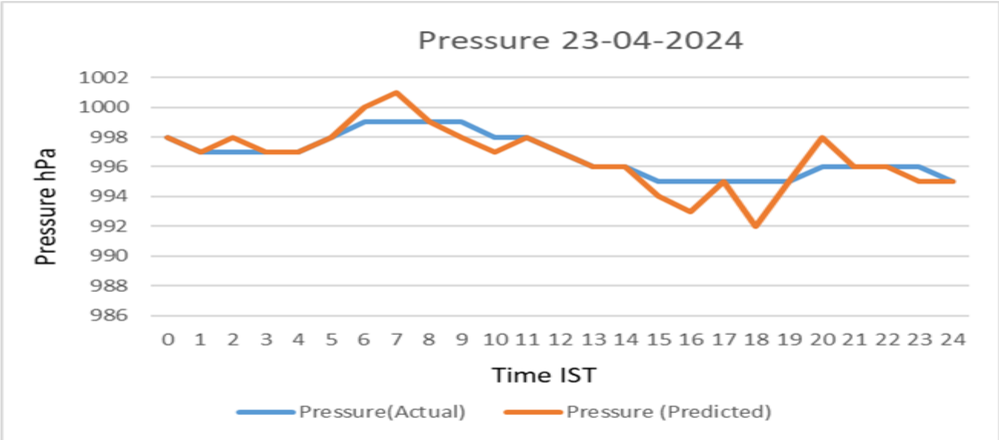


Fig. 4.9 Actual and Predicted Pressure

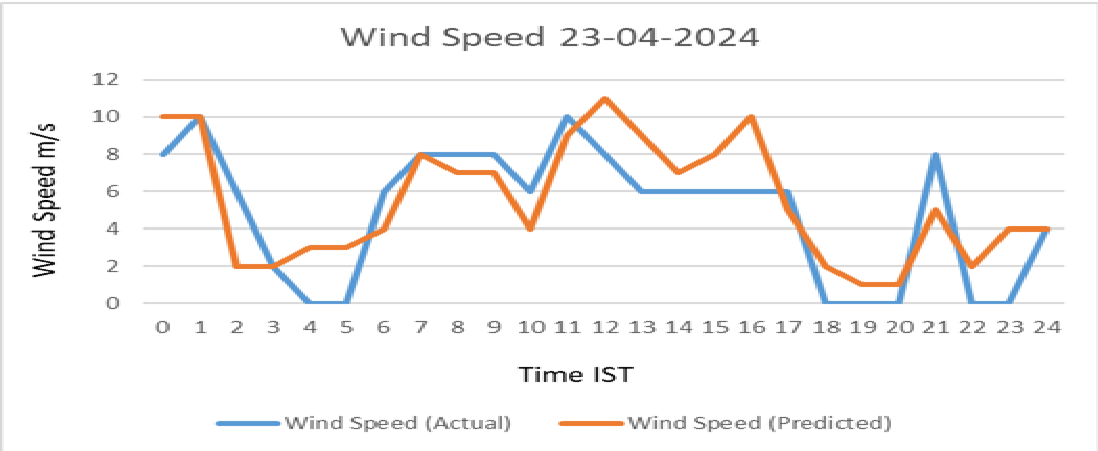


Fig. 4.10 Actual and Predicted Wind Speed

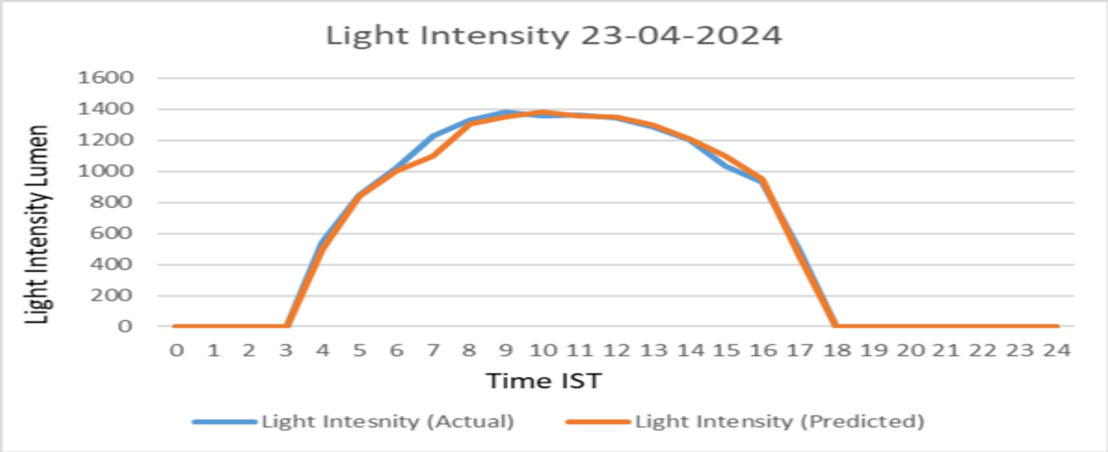


Fig. 4.11 Actual and Predicted Light Intensity

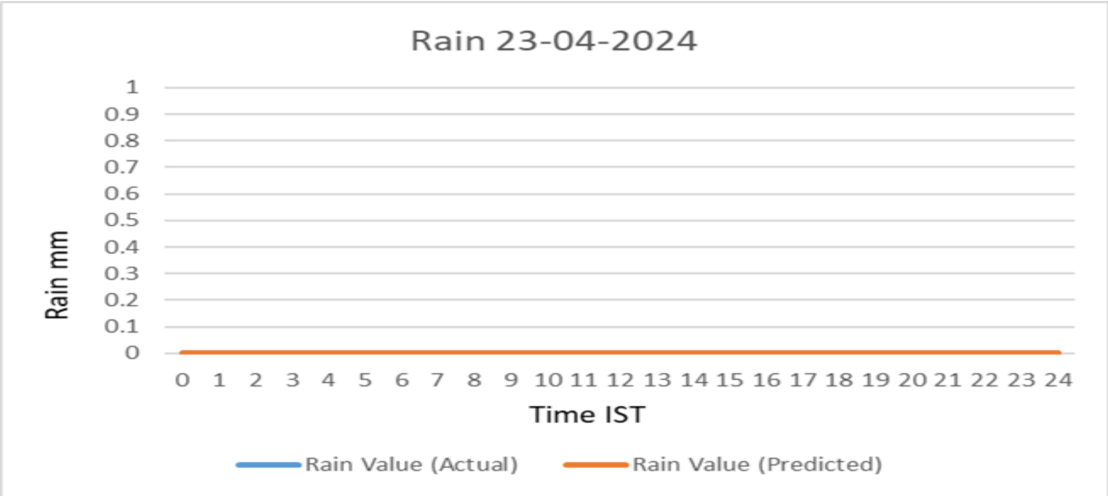


Fig. 4.12 Actual and Predicted Rain

Table 3: Predicted and actual data (24-04-2024)

S.No	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(	Pressure (
1	24-04-2024	00:00:00	25	24	92	86	0	0	0	0	8	10	995	995
2	24-04-2024	01:00:00	24	25	92	90	0	0	0	0	8	10	995	995
3	24-04-2024	02:00:00	24	26	92	89	0	0	0	0	0	2	995	993
4	24-04-2024	03:00:00	24	26	92	87	0	0	0	0	0	2	995	995
5	24-04-2024	04:00:00	24	25	92	95	200	250	0	0	0	3	995	994
6	24-04-2024	05:00:00	24	25	92	94	351	368	0	0	0	3	995	997
7	24-04-2024	06:00:00	26	25	78	85	864	900	0	0	0	0	996	996
8	24-04-2024	07:00:00	29	27	72	88	1088	1005	0	0	0	0	997	998
9	24-04-2024	08:00:00	31	30	36	50	1181	1180	0	0	0	1	998	998
10	24-04-2024	09:00:00	32	30	46	55	1262	1256	0	0	6	5	998	997
11	24-04-2024	10:00:00	33	33	42	40	1328	1375	0	0	0	4	998	999
12	24-04-2024	11:00:00	35	33	35	39	1366	1343	0	0	12	10	997	998
13	24-04-2024	12:00:00	36	33	28	35	1375	1375	0	0	16	15	996	996
14	24-04-2024	13:00:00	37	39	19	30	1268	1250	0	0	16	15	995	995
15	24-04-2024	14:00:00	37	38	9	12	1353	1348	0	0	20	17	994	994
16	24-04-2024	15:00:00	37	40	12	12	1231	1230	0	0	16	13	993	993
17	24-04-2024	16:00:00	37	40	6	10	881	883	0	0	16	16	993	995
18	24-04-2024	17:00:00	36	34	14	15	542	538	0	0	20	22	993	993
19	24-04-2024	18:00:00	35	35	16	19	335	327	0	0	22	24	994	994
20	24-04-2024	19:00:00	33	32	21	20	0	0	0	0	16	18	995	993
21	24-04-2024	20:00:00	32	29	25	30	0	0	0	0	16	15	996	996
22	24-04-2024	21:00:00	31	33	18	25	0	0	0	0	20	19	996	993
23	24-04-2024	22:00:00	31	32	18	20	0	0	0	0	16	18	997	996
24	24-04-2024	23:00:00	31	30	18	16	0	0	0	0	16	14	996	994
25	24-04-2024	24:00:00	28	27	47	50	0	0	0	0	14	15	997	997

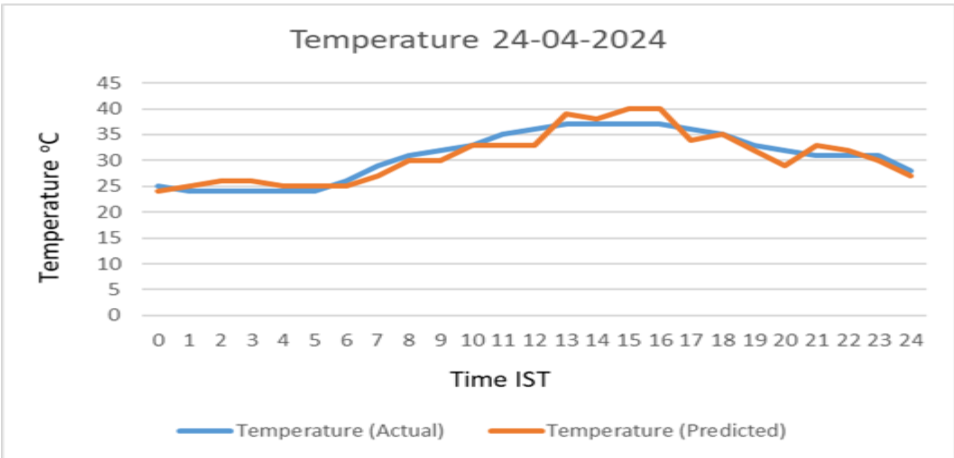


Fig. 4.13 Actual and Predicted Temperature

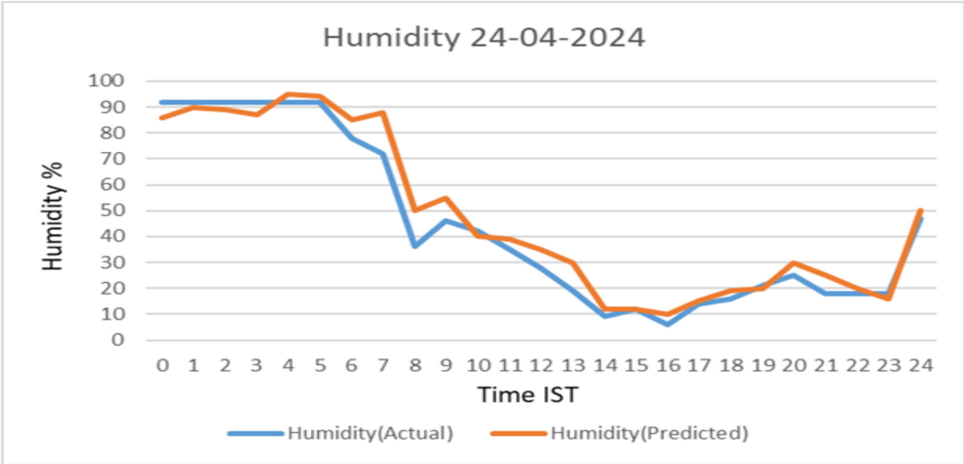


Fig. 4.14 Actual and Predicted Humidity

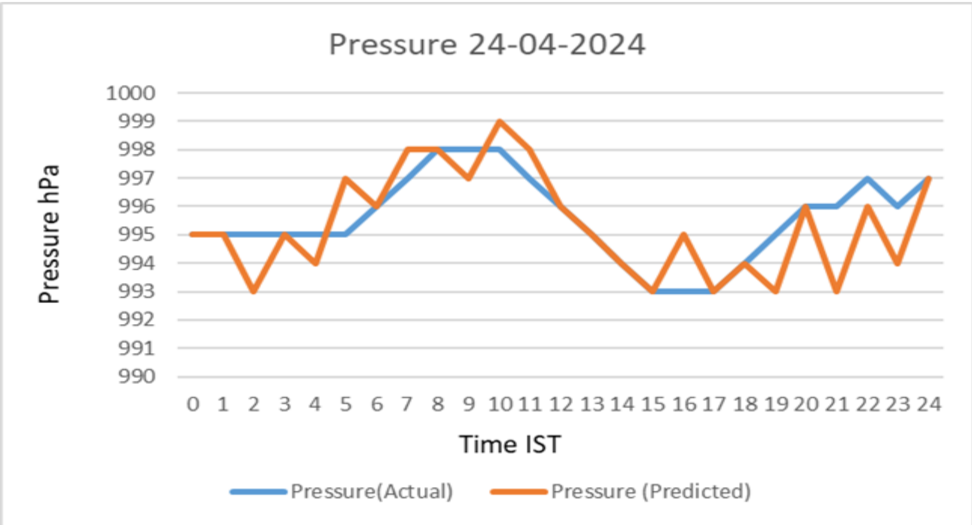


Fig. 4.15 Actual and Predicted Pressure

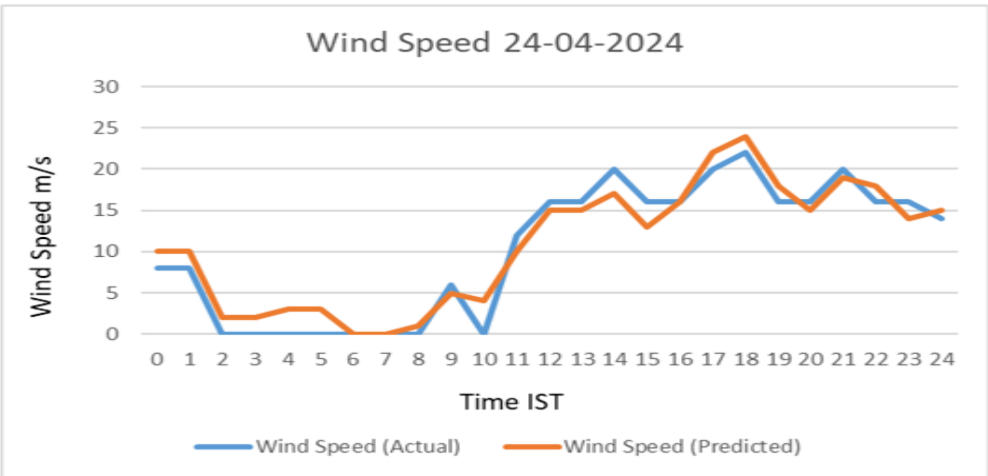


Fig. 4.16 Actual and Predicted Wind Speed

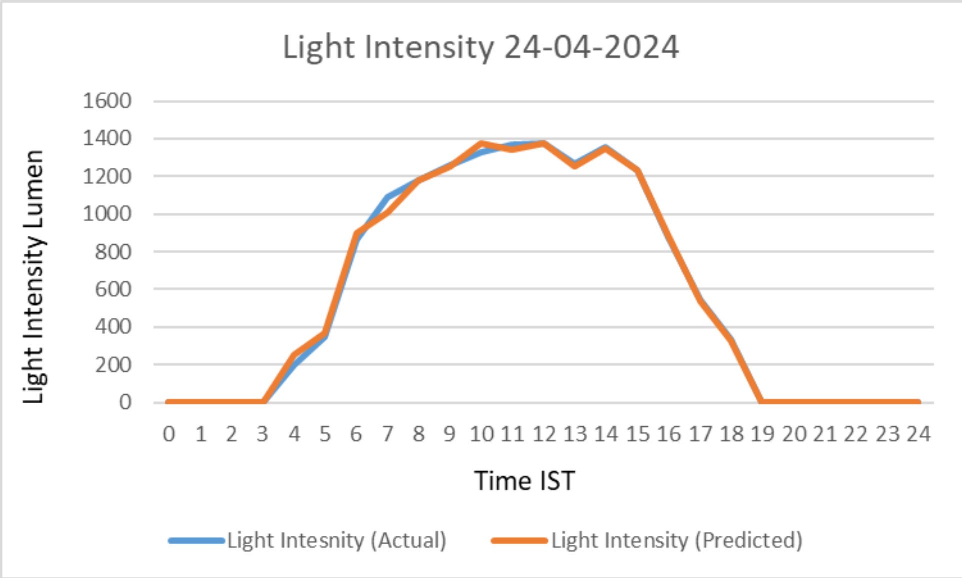


Fig. 4.17 Actual and Predicted Light Intensity

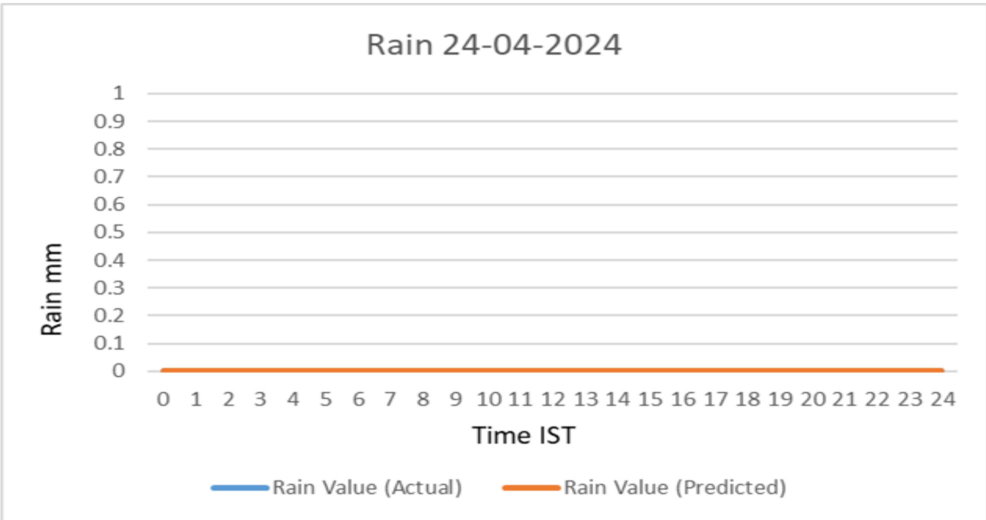


Fig. 4.18 Actual and Predicted Rain

Table 4: Predicted and actual data (25-04-2024)

S.No	Date	Time	Temperatu	Temperatu	Humidity(/	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(/	Pressure (I
1	25-04-2024	00:00:00	27	24	47	50	0	0	0	0	8	9	997	995
2	25-04-2024	01:00:00	24	25	58	62	0	0	0	0	8	10	996	995
3	25-04-2024	02:00:00	24	26	84	89	0	0	0	0	0	2	998	993
4	25-04-2024	03:00:00	24	26	84	87	351	320	0	0	0	2	998	999
5	25-04-2024	04:00:00	24	25	77	75	421	401	0	0	0	0	997	994
6	25-04-2024	05:00:00	25	25	84	89	450	438	0	0	0	3	998	997
7	25-04-2024	06:00:00	26	25	77	80	468	489	0	0	0	4	998	996
8	25-04-2024	07:00:00	27	27	71	75	514	569	0	0	0	1	999	998
9	25-04-2024	08:00:00	29	30	65	60	761	789	0	0	0	1	1000	998
10	25-04-2024	09:00:00	30	30	54	55	943	950	0	0	6	7	1000	997
11	25-04-2024	10:00:00	31	33	49	47	913	930	0	0	0	0	1000	999
12	25-04-2024	11:00:00	31	33	45	49	1130	1123	0	0	12	14	999	998
13	25-04-2024	12:00:00	33	33	35	35	1230	1223	0	0	16	20	999	996
14	25-04-2024	13:00:00	33	35	33	30	1081	1080	0	0	16	18	997	995
15	25-04-2024	14:00:00	33	31	32	30	1030	1017	0	0	20	16	996	997
16	25-04-2024	15:00:00	32	31	32	31	846	873	0	0	16	14	996	993
17	25-04-2024	16:00:00	33	30	32	31	301	378	0	0	16	14	995	995
18	25-04-2024	17:00:00	30	28	33	31	120	154	0	0	20	12	996	993
19	25-04-2024	18:00:00	30	26	44	48	0	0	0	0	22	19	996	994
20	25-04-2024	19:00:00	29	30	44	45	0	0	0	0	16	13	997	995
21	25-04-2024	20:00:00	29	29	48	44	0	0	0	0	16	17	998	997
22	25-04-2024	21:00:00	27	25	48	43	0	0	0	0	20	21	998	993
23	25-04-2024	22:00:00	26	28	65	66	0	0	0	0	16	15	998	996
24	25-04-2024	23:00:00	26	29	71	70	0	0	0	0	16	14	998	994
25	25-04-2024	24:00:00	26	27	64	60	0	0	0	0	14	12	998	997

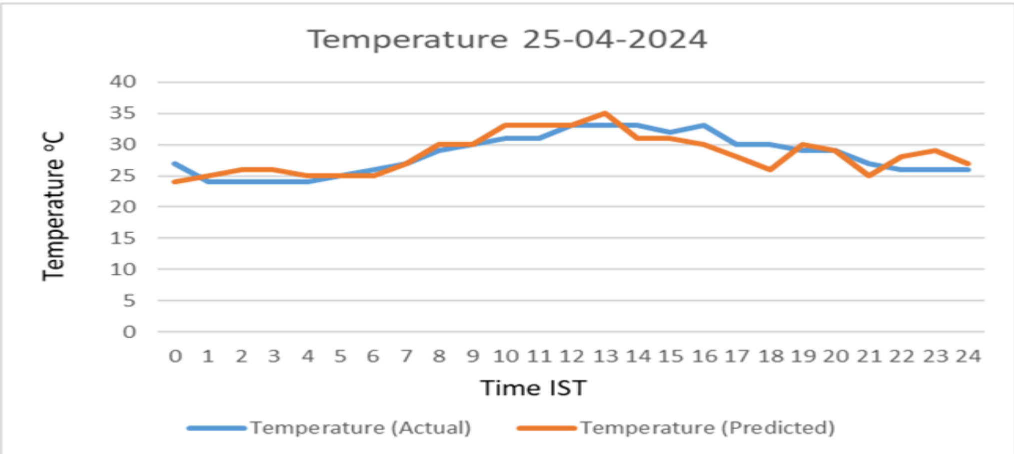


Fig. 4.19 Actual and Predicted Temperature

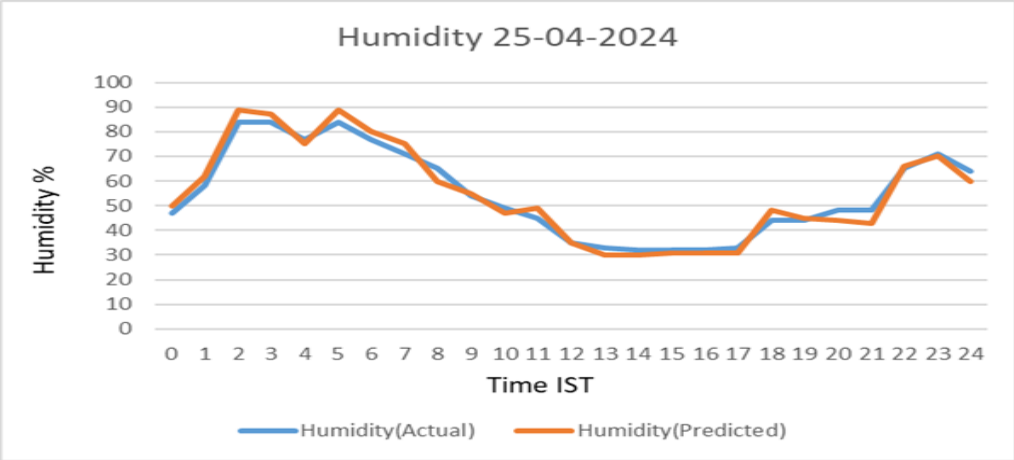


Fig. 4.20 Actual and Predicted Humidity

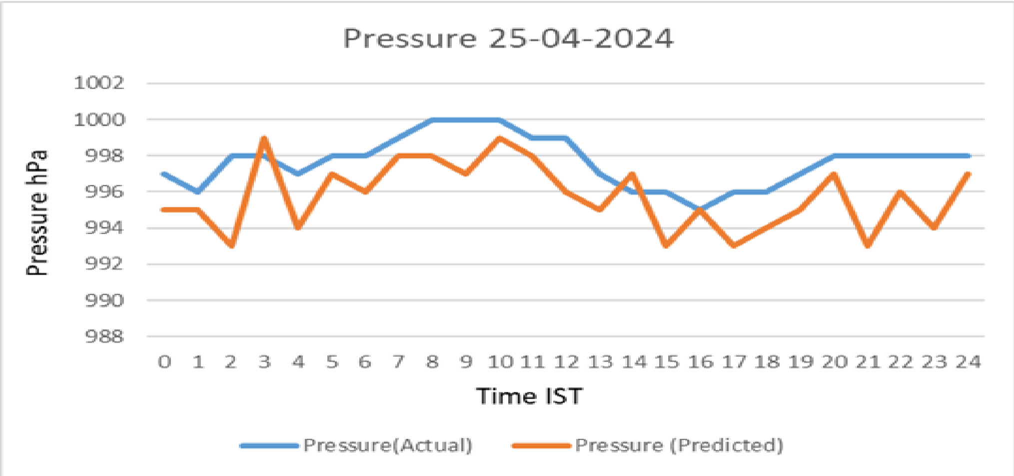


Fig. 4.21 Actual and Predicted Pressure

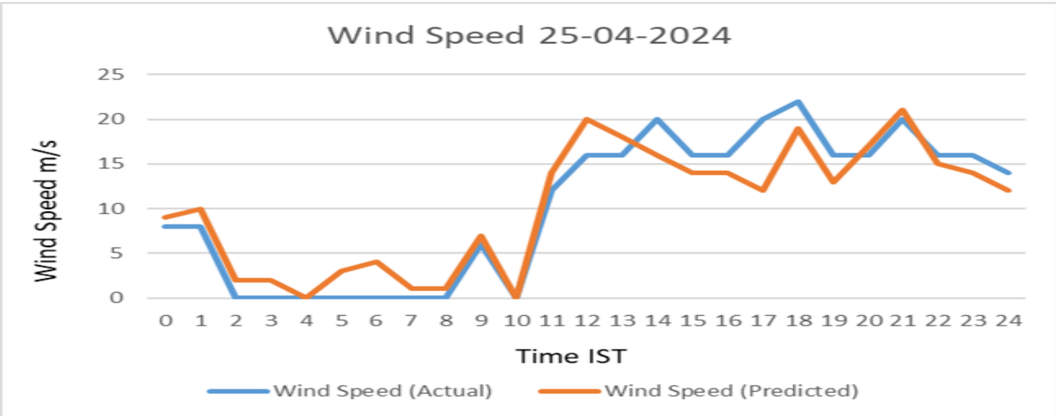


Fig. 4.22 Actual and Predicted Wind Speed

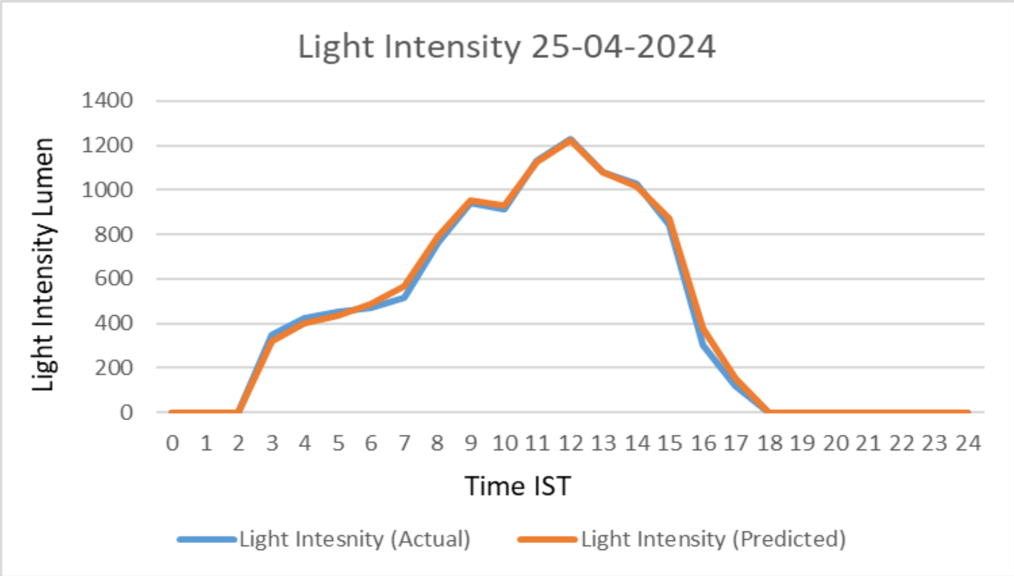


Fig. 4.23 Actual and Predicted Light Intensity

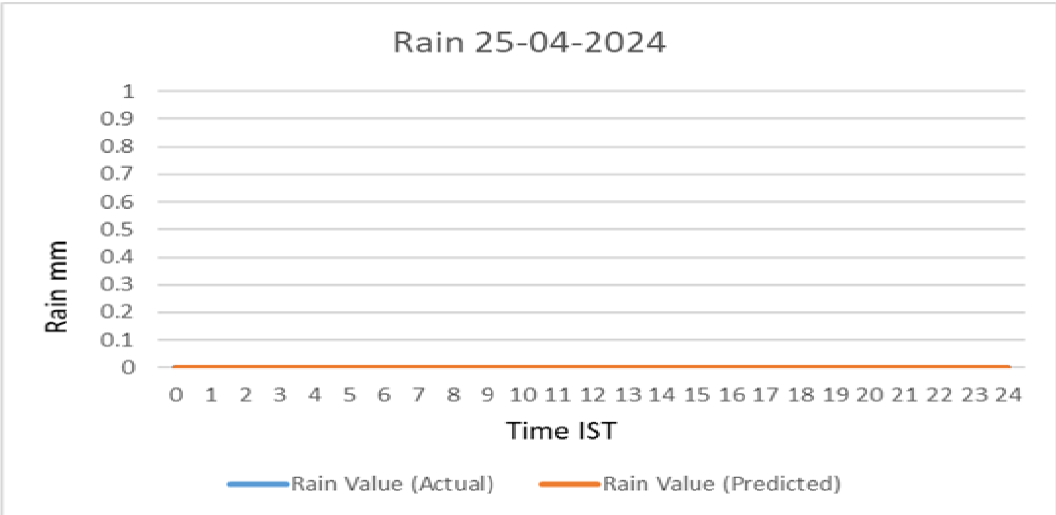


Fig. 4.24 Actual and Predicted Rain

Table 5: Predicted and actual data (26-04-2024)

S.No	Date	Time	Temperatı	Temperatı	Humidity(/	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(/	Pressure (
1	26-04-2024	00:00:00	26	24	64	66	0	0	0	0	12	9	998	998
2	26-04-2024	01:00:00	24	25	77	80	0	0	0	0	12	10	998	998
3	26-04-2024	02:00:00	25	26	70	75	0	0	0	0	12	10	998	999
4	26-04-2024	03:00:00	25	26	77	75	320	380	0	0	10	11	998	998
5	26-04-2024	04:00:00	24	25	84	83	401	421	0	0	10	12	999	999
6	26-04-2024	05:00:00	24	25	84	85	438	450	0	0	10	10	999	999
7	26-04-2024	06:00:00	25	25	77	80	489	468	0	0	10	9	1000	1000
8	26-04-2024	07:00:00	26	27	78	75	569	514	0	0	14	15	1000	1000
9	26-04-2024	08:00:00	28	30	59	60	789	761	0	0	16	15	1000	1001
10	26-04-2024	09:00:00	29	30	54	55	950	943	0	0	12	12	1000	1000
11	26-04-2024	10:00:00	30	33	49	47	930	913	0	0	20	18	1000	999
12	26-04-2024	11:00:00	31	33	45	49	1123	1130	0	0	10	14	999	999
13	26-04-2024	12:00:00	33	33	33	35	1223	1230	0	0	22	20	999	998
14	26-04-2024	13:00:00	33	35	33	30	1080	1081	0	0	24	22	997	997
15	26-04-2024	14:00:00	33	31	76	78	1017	1030	0	0	24	22	997	997
16	26-04-2024	15:00:00	33	31	76	76	873	846	0	0	16	14	996	996
17	26-04-2024	16:00:00	33	30	25	29	378	301	0	0	14	14	996	995
18	26-04-2024	17:00:00	33	29	25	27	154	120	0	0	18	15	996	996
19	26-04-2024	18:00:00	30	30	34	39	0	0	0	0	10	12	996	996
20	26-04-2024	19:00:00	29	30	48	45	0	0	0	0	12	13	998	998
21	26-04-2024	20:00:00	28	29	53	50	0	0	0	0	16	17	999	997
22	26-04-2024	21:00:00	26	25	71	70	0	0	0	0	14	13	999	999
23	26-04-2024	22:00:00	26	28	71	71	0	0	0	0	10	14	999	998
24	26-04-2024	23:00:00	26	29	71	70	0	0	0	0	14	14	999	999
25	26-04-2024	24:00:00	25	27	77	78	0	0	0	0	18	15	999	999

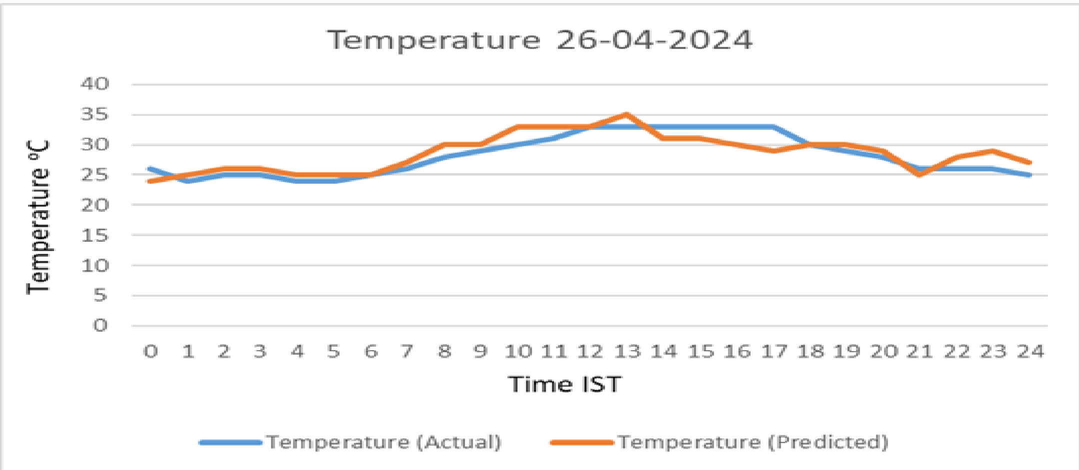


Fig. 4.25 Actual and Predicted Temperature

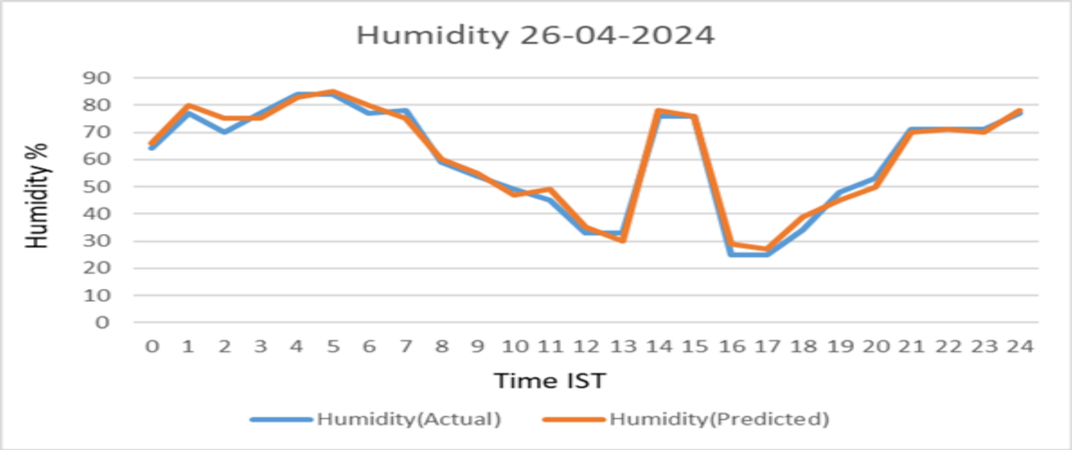


Fig. 4.26 Actual and Predicted Humidity

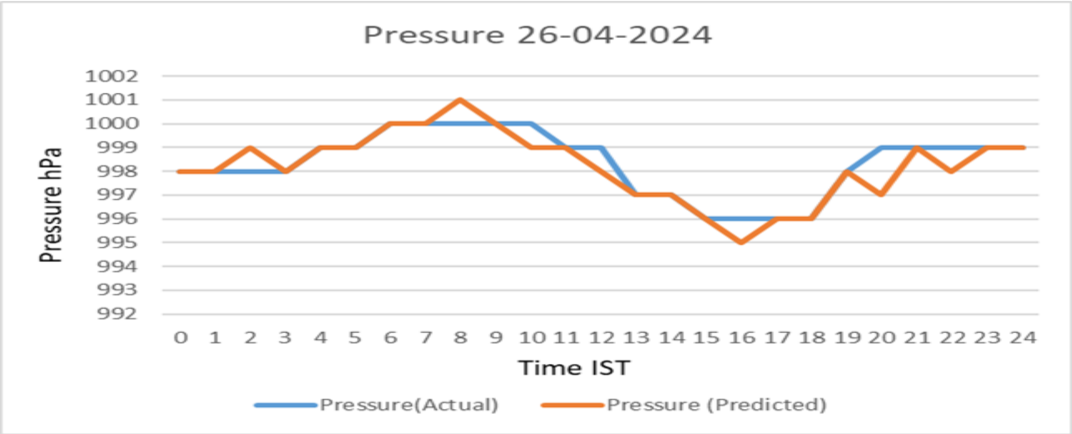


Fig. 4.27 Actual and Predicted Pressure

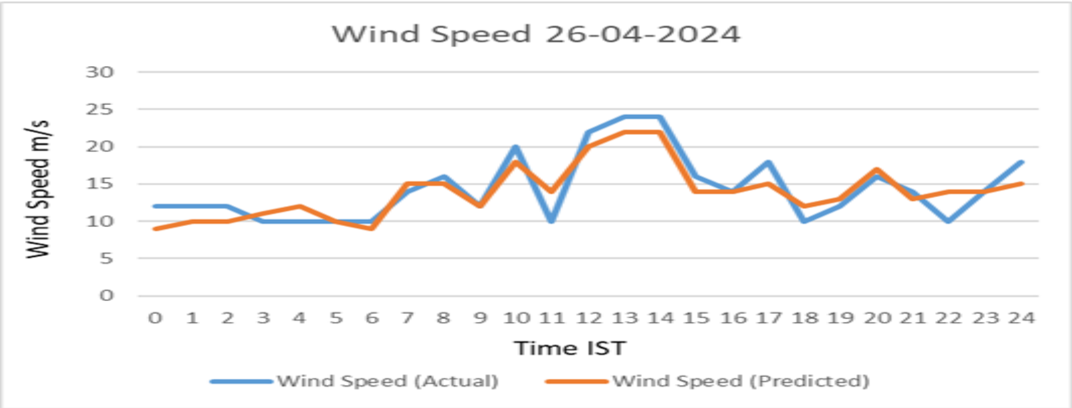


Fig. 4.28 Actual and Predicted Wind Speed

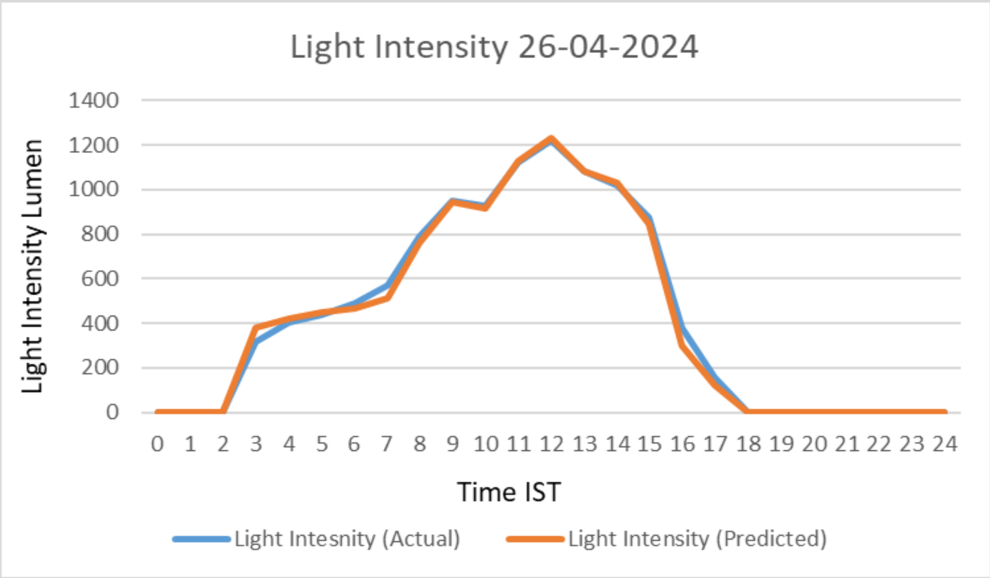


Fig. 4.29 Actual and Predicted Light Intensity

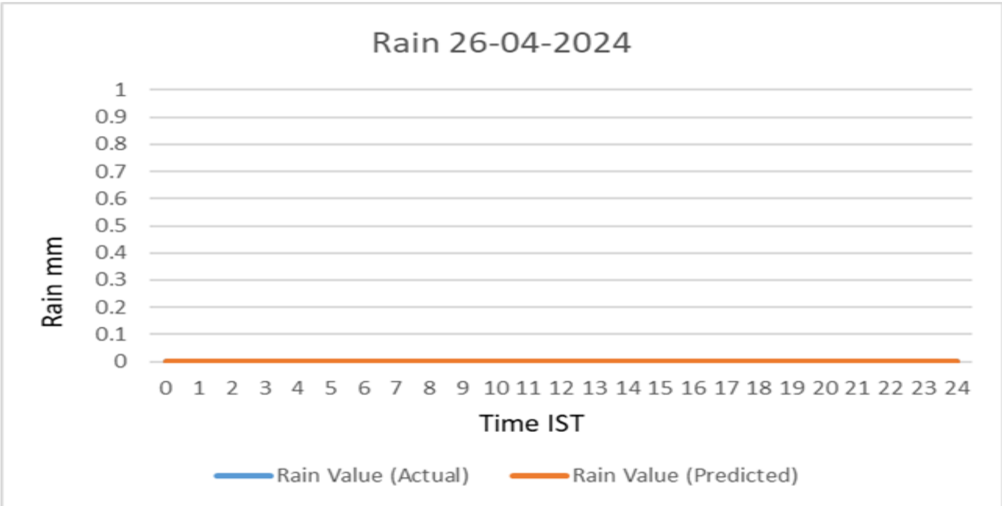


Fig. 4.30 Actual and Predicted Rain

Table 6: Predicted and actual data (27-04-2024)

Sl No.	Date	Time	Temperatu	Temperatu	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(A	Pressure (
1	27-04-2024	00:00:00	25	24	77	85	0	0	0	0	18	15	998	996
2	27-04-2024	01:00:00	25	25	84	90	0	0	0	0	12	10	999	999
3	27-04-2024	02:00:00	24	26	84	86	0	0	0	0	8	8	1000	999
4	27-04-2024	03:00:00	24	26	84	87	464	400	0	0	16	16	1001	1000
5	27-04-2024	04:00:00	24	25	84	95	571	580	0	0	12	11	1001	999
6	27-04-2024	05:00:00	25	25	77	84	684	674	0	0	10	12	1001	998
7	27-04-2024	06:00:00	25	25	77	80	891	890	0	0	10	9	1002	1000
8	27-04-2024	07:00:00	25	27	84	88	1292	1290	0	0	14	12	1002	1001
9	27-04-2024	08:00:00	27	30	65	71	1301	1300	0	0	14	10	1001	1000
10	27-04-2024	09:00:00	29	30	54	53	1308	1349	0	0	16	12	1001	1002
11	27-04-2024	10:00:00	31	33	45	43	1167	1245	0	0	12	12	1000	999
12	27-04-2024	11:00:00	32	33	46	50	1328	1299	0	0	14	17	999	999
13	27-04-2024	12:00:00	32	33	46	50	1320	1300	0	0	20	15	998	998
14	27-04-2024	13:00:00	33	33	38	40	1295	1296	0	0	16	15	997	997
15	27-04-2024	14:00:00	33	34	33	31	1064	1023	0	0	14	11	997	996
16	27-04-2024	15:00:00	33	34	33	32	825	785	0	0	16	10	996	994
17	27-04-2024	16:00:00	33	34	33	38	0	0	0	0	14	16	997	996
18	27-04-2024	17:00:00	32	32	37	41	0	0	0	0	10	10	997	995
19	27-04-2024	18:00:00	30	29	44	42	0	0	0	0	10	8	998	997
20	27-04-2024	19:00:00	29	27	54	58	0	0	0	0	6	4	998	998
21	27-04-2024	20:00:00	29	28	54	60	0	0	0	0	4	3	998	998
22	27-04-2024	21:00:00	28	26	59	60	0	0	0	0	8	5	998	1000
23	27-04-2024	22:00:00	28	25	65	70	0	0	0	0	8	7	998	1001
24	27-04-2024	23:00:00	27	26	64	60	0	0	0	0	10	6	998	1000
25	27-04-2024	24:00:00	25	25	84	86	0	0	0	0	14	10	997	1000

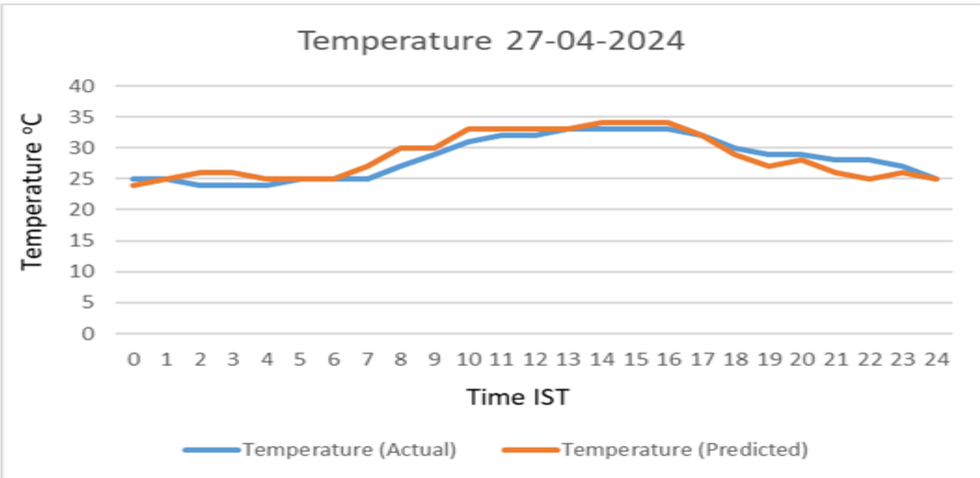


Fig. 4.31 Actual and Predicted Temperature

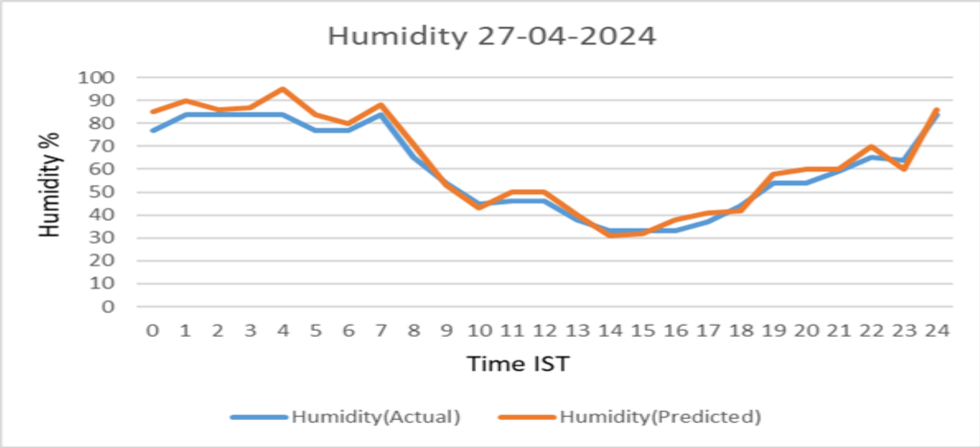


Fig. 4.32 Actual and Predicted Humidity

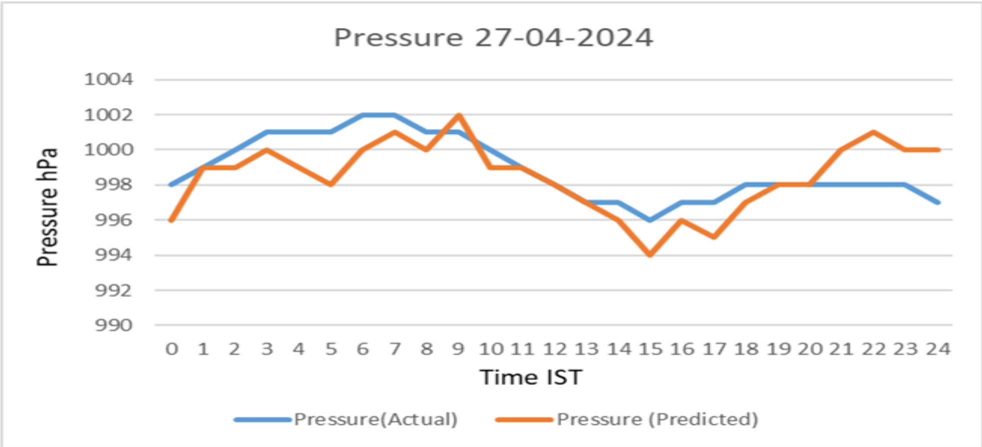


Fig. 4.33 Actual and Predicted Pressure

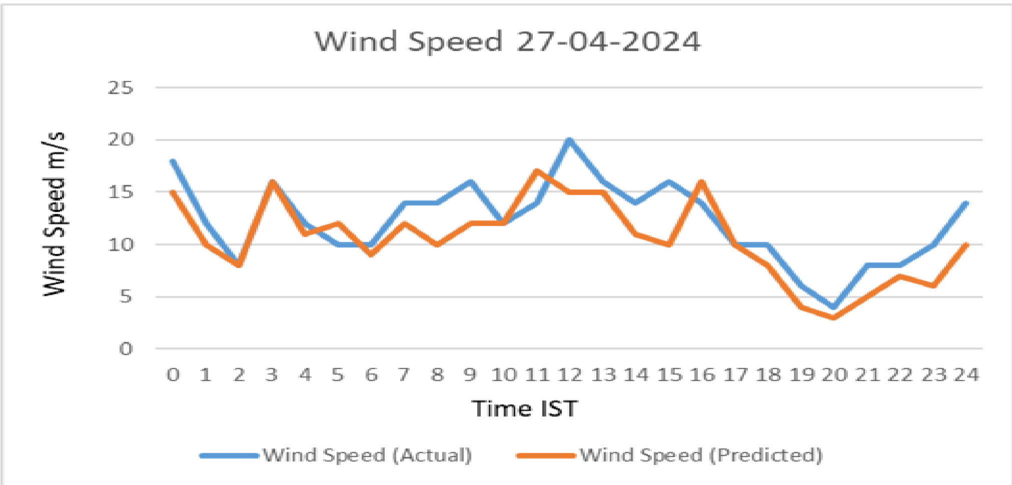


Fig. 4.34 Actual and Predicted Wind Speed

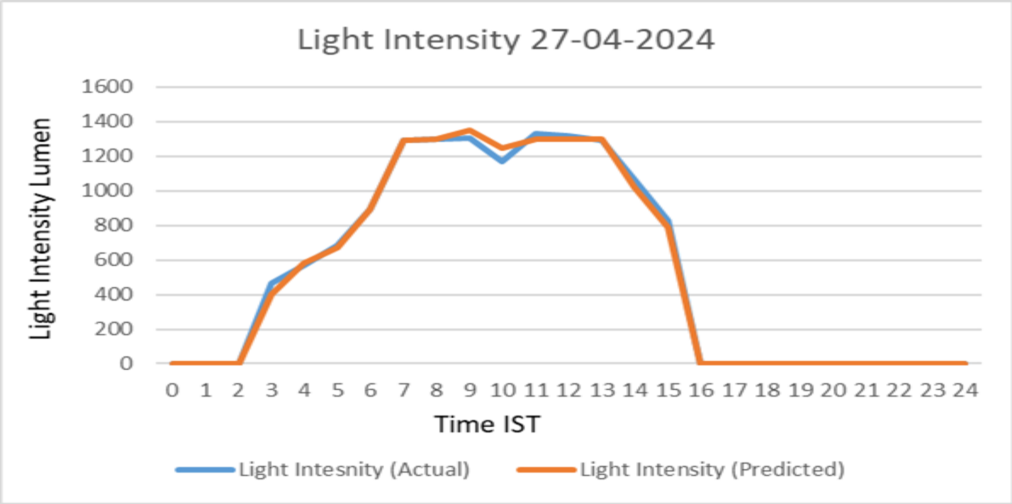


Fig. 4.35 Actual and Predicted Light Intensity

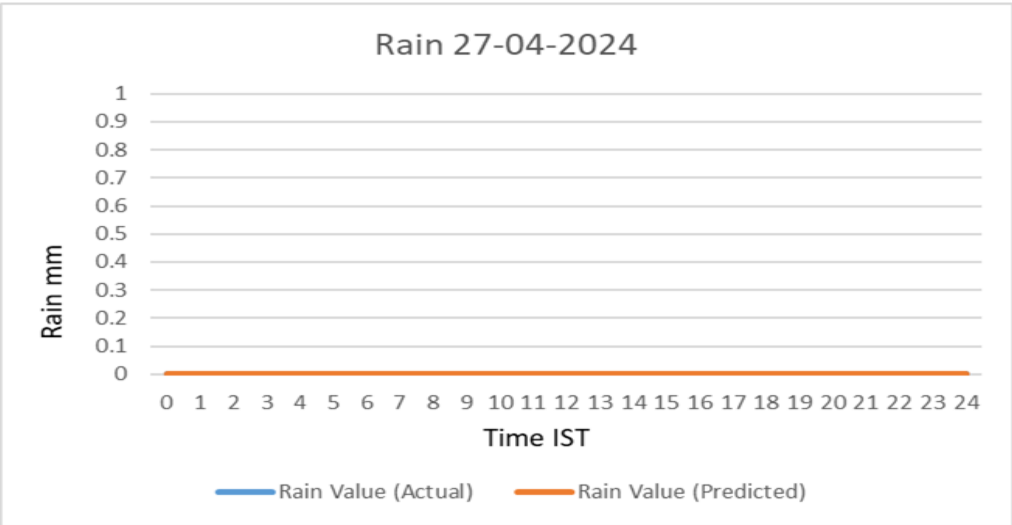


Fig. 4.36 Actual and Predicted Rain

Table 7: Predicted and actual data (28-04-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	28-04-2024	00:00:00	25	24	84	85	0	0	0	0	14	15	997	996
2	28-04-2024	01:00:00	25	25	84	90	0	0	0	0	10	10	996	999
3	28-04-2024	02:00:00	25	26	92	91	0	0	0	0	10	8	996	999
4	28-04-2024	03:00:00	25	26	92	89	421	400	0	0	4	5	997	1000
5	28-04-2024	04:00:00	25	25	92	95	564	580	0	0	4	8	997	999
6	28-04-2024	05:00:00	25	25	92	88	682	674	0	0	8	10	998	998
7	28-04-2024	06:00:00	26	25	92	90	890	890	0	0	8	9	998	1000
8	28-04-2024	07:00:00	28	27	84	88	1100	1290	0	0	14	12	998	1001
9	28-04-2024	08:00:00	30	30	71	71	1231	1300	0	0	12	10	999	1000
10	28-04-2024	09:00:00	32	30	60	59	1242	1349	0	0	12	12	999	1002
11	28-04-2024	10:00:00	32	33	51	49	1249	1245	0	0	18	20	999	999
12	28-04-2024	11:00:00	34	33	51	50	1259	1299	0	0	12	16	998	999
13	28-04-2024	12:00:00	34	33	43	45	1282	1300	0	0	6	4	997	998
14	28-04-2024	13:00:00	34	33	47	45	1247	1296	0	0	18	20	996	997
15	28-04-2024	14:00:00	32	34	47	50	921	1023	0	0	20	13	996	996
16	28-04-2024	15:00:00	31	34	56	52	864	785	0	0	16	10	995	994
17	28-04-2024	16:00:00	29	34	61	54	521	499	0	0	20	16	994	996
18	28-04-2024	17:00:00	28	30	59	60	345	330	0	0	24	22	995	995
19	28-04-2024	18:00:00	27	29	65	70	0	0	0	0	30	25	996	997
20	28-04-2024	19:00:00	27	27	64	65	0	0	0	0	22	20	997	998
21	28-04-2024	20:00:00	26	28	71	69	0	0	0	0	14	15	998	998
22	28-04-2024	21:00:00	25	26	70	72	0	0	0	0	14	15	999	1000
23	28-04-2024	22:00:00	25	25	84	80	0	0	0	0	14	10	1000	1001
24	28-04-2024	23:00:00	25	26	84	89	0	0	0	0	14	12	1000	1000
25	28-04-2024	24:00:00	25	25	77	78	0	0	0	0	20	21	999	1000

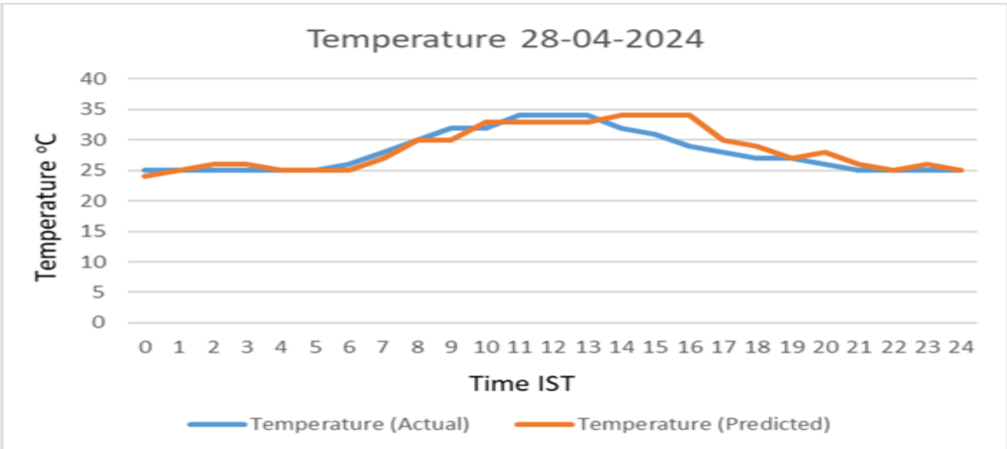


Fig. 4.37 Actual and Predicted Temperature

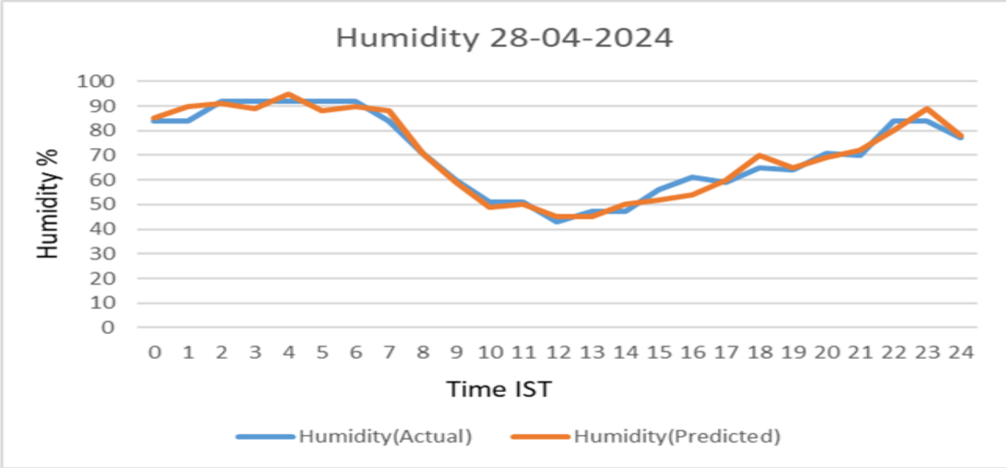


Fig. 4.38 Actual and Predicted Humidity

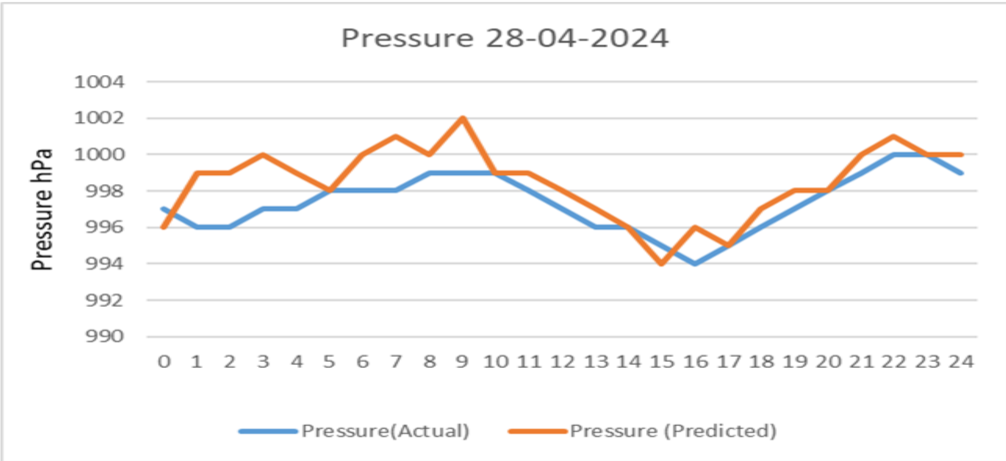


Fig. 4.39 Actual and Predicted Pressure

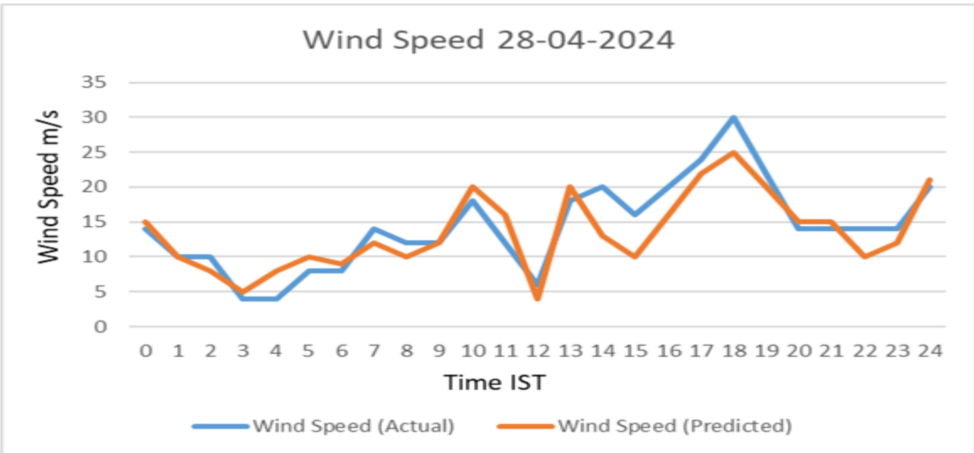


Fig. 4.40 Actual and Predicted Wind Speed

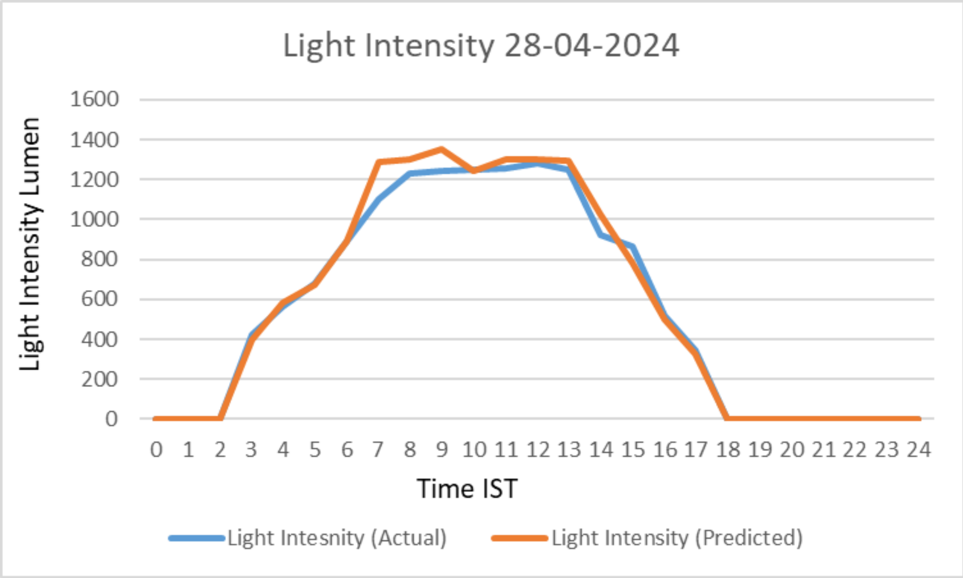


Fig. 4.41 Actual and Predicted Light Intensity

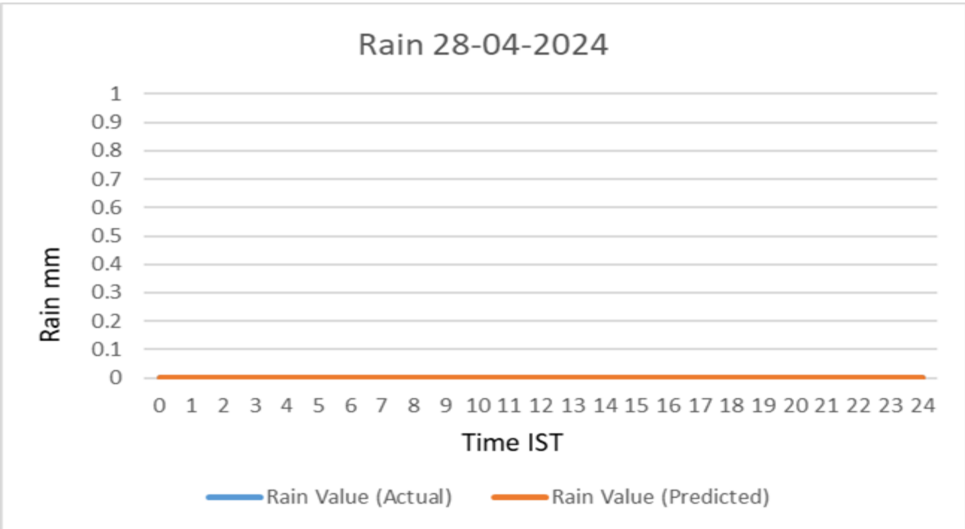


Fig. 4.42 Actual and Predicted Rain

Table 8: Predicted and actual data (29-04-2024)

Sl No.	Date	Time	Temperatı	Temperatı	Humidity(/	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(/	Pressure (I
1	29-04-2024	00:00:00	25	24	77	85	0	0	0	0	20	17	999	998
2	29-04-2024	01:00:00	24	25	84	90	0	0	0	0	18	14	999	999
3	29-04-2024	02:00:00	23	26	84	86	0	0	0	0	20	22	999	999
4	29-04-2024	03:00:00	23	26	84	87	464	400	0	0	16	16	999	1000
5	29-04-2024	04:00:00	23	25	84	95	571	580	0	0	14	11	999	999
6	29-04-2024	05:00:00	23	25	77	84	924	674	0	0	12	12	1000	998
7	29-04-2024	06:00:00	23	25	77	80	891	890	0	0	10	9	1000	1000
8	29-04-2024	07:00:00	24	27	84	88	1292	1290	0	0	18	12	1001	1001
9	29-04-2024	08:00:00	26	30	65	71	1301	1300	0	0	16	10	1001	1000
10	29-04-2024	09:00:00	27	30	54	53	1308	1349	0	0	16	14	1001	1002
11	29-04-2024	10:00:00	29	33	45	43	1167	1245	0	0	20	18	1001	999
12	29-04-2024	11:00:00	30	33	46	50	1328	1299	0	0	16	17	1000	999
13	29-04-2024	12:00:00	32	33	46	50	1320	1300	0	0	16	15	999	998
14	29-04-2024	13:00:00	32	33	38	40	1295	1296	0	0	18	15	998	997
15	29-04-2024	14:00:00	33	34	33	31	1064	1023	0	0	18	15	997	996
16	29-04-2024	15:00:00	33	34	33	32	825	785	0	0	12	10	996	994
17	29-04-2024	16:00:00	33	34	33	38	741	730	0	0	12	16	996	996
18	29-04-2024	17:00:00	32	32	37	41	610	600	0	0	10	10	996	995
19	29-04-2024	18:00:00	30	29	44	42	0	0	0	0	10	8	997	997
20	29-04-2024	19:00:00	29	27	54	58	0	0	0	0	8	8	997	998
21	29-04-2024	20:00:00	30	28	54	60	0	0	0	0	8	4	997	998
22	29-04-2024	21:00:00	28	26	59	60	0	0	0	0	8	5	998	1000
23	29-04-2024	22:00:00	27	25	65	70	0	0	0	0	8	7	998	1001
24	29-04-2024	23:00:00	26	26	64	60	0	0	0	0	12	10	998	1000
25	29-04-2024	24:00:00	26	25	84	86	0	0	0	0	12	10	997	1000

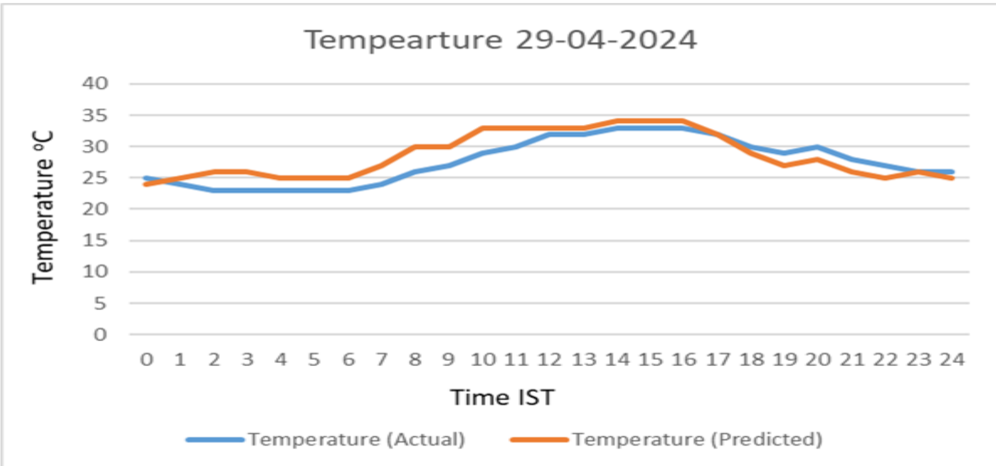


Fig. 4.43 Actual and Predicted Temperature

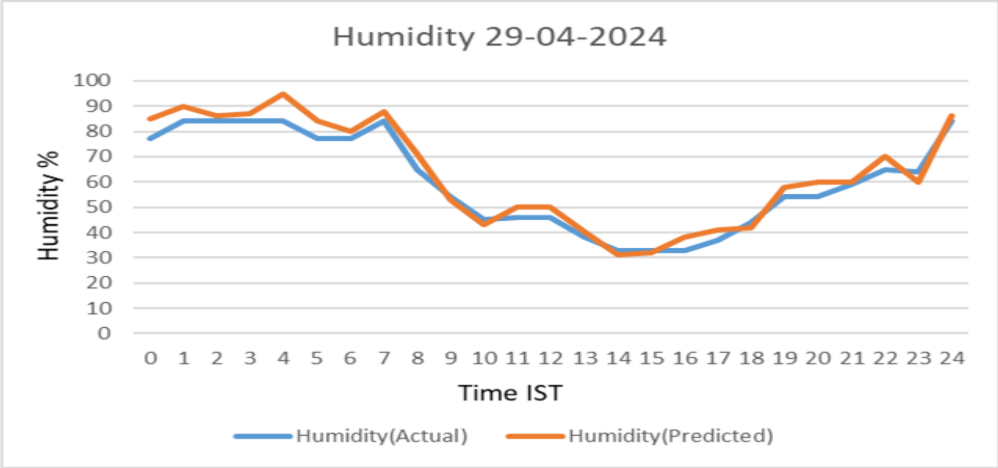


Fig. 4.44 Actual and Predicted Humidity

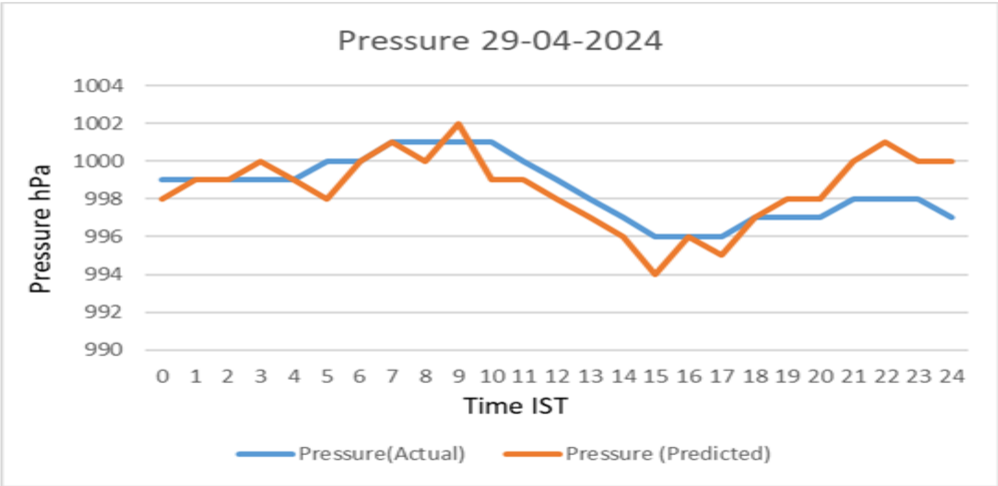


Fig. 4.45 Actual and Predicted Pressure

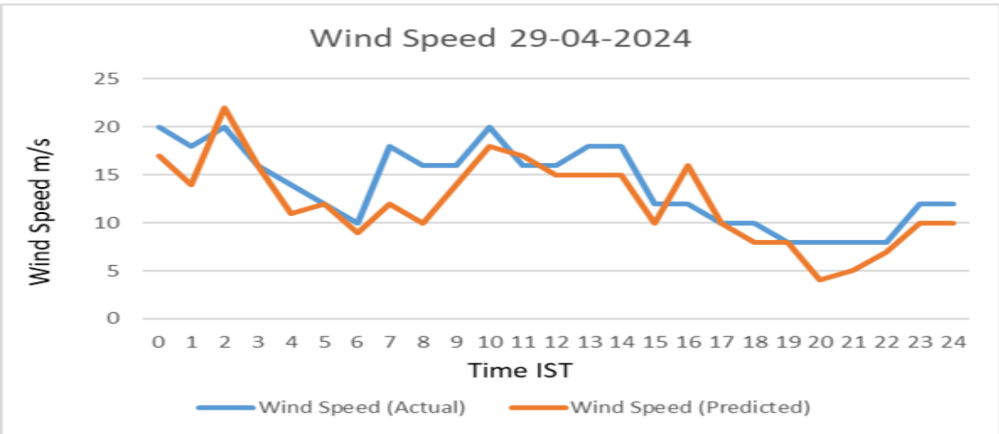


Fig. 4.46 Actual and Predicted Wind Speed

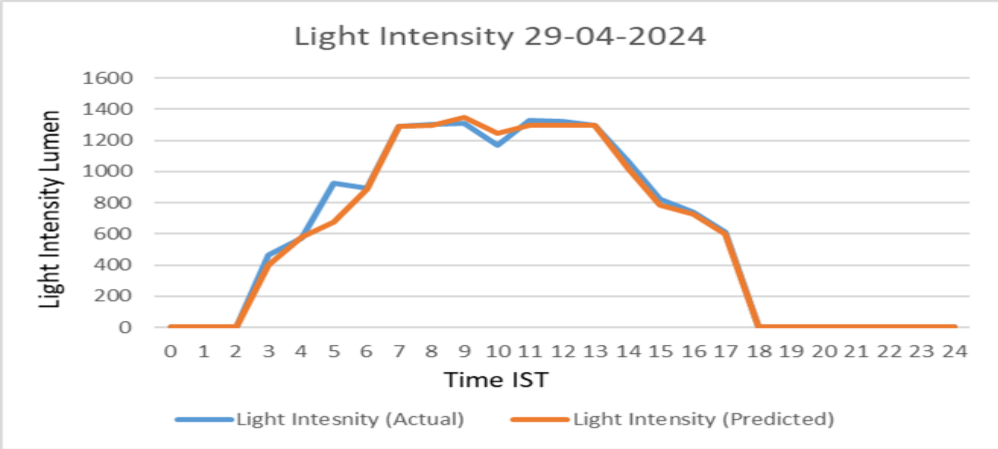


Fig. 4.47 Actual and Predicted Light Intensity

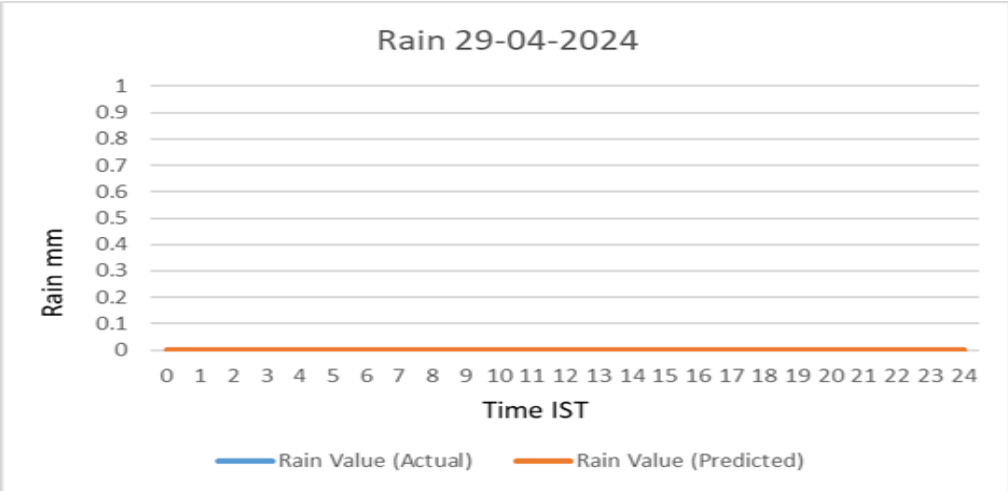


Fig. 4.48 Actual and Predicted Rain

Table 9: Predicted and actual data (30-04-2024)

Sl No.	Date	Time	Temperatı	Temperatı	Humidity(.	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(A	Pressure (
1	30-04-2024	00:00:00	26	24	77	80	0	0	0	0	12	17	997	998
2	30-04-2024	01:00:00	25	25	84	90	0	0	0	0	9	10	995	993
3	30-04-2024	02:00:00	25	26	77	75	0	0	0	0	10	12	995	993
4	30-04-2024	03:00:00	25	26	77	78	0	0	0	0	12	16	995	995
5	30-04-2024	04:00:00	24	25	92	95	28	30	0	0	12	11	996	999
6	30-04-2024	05:00:00	24	25	84	84	58	60	0	0	10	12	996	998
7	30-04-2024	06:00:00	24	25	92	90	223	225	0	0	12	9	996	994
8	30-04-2024	07:00:00	27	27	71	68	452	460	0	0	12	12	997	998
9	30-04-2024	08:00:00	28	30	65	67	682	689	0	0	14	10	997	999
10	30-04-2024	09:00:00	29	30	59	53	797	801	0	0	10	14	997	1000
11	30-04-2024	10:00:00	30	33	54	58	964	987	0	0	14	18	997	999
12	30-04-2024	11:00:00	31	33	50	50	1020	1100	0	0	18	17	996	999
13	30-04-2024	12:00:00	33	33	42	40	1002	1001	0	0	10	15	994	998
14	30-04-2024	13:00:00	33	33	37	40	835	832	0	0	26	23	993	995
15	30-04-2024	14:00:00	33	34	37	35	706	701	0	0	12	15	992	993
16	30-04-2024	15:00:00	33	34	33	32	555	556	0	0	20	10	991	993
17	30-04-2024	16:00:00	33	34	42	40	264	235	0	0	16	16	991	992
18	30-04-2024	17:00:00	31	32	45	41	150	145	0	0	20	21	991	990
19	30-04-2024	18:00:00	30	29	49	42	0	0	0	0	14	15	993	997
20	30-04-2024	19:00:00	29	27	54	58	0	0	0	0	16	17	993	998
21	30-04-2024	20:00:00	27	28	64	60	0	0	0	0	10	9	999	998
22	30-04-2024	21:00:00	26	26	70	68	0	0	0	0	22	24	999	1000
23	30-04-2024	22:00:00	26	25	70	70	0	0	0	0	20	18	999	1001
24	30-04-2024	23:00:00	24	26	84	89	0	0	0	0	16	15	999	1000
25	30-04-2024	24:00:00	24	25	76	80	0	0	0	0	16	10	999	1000

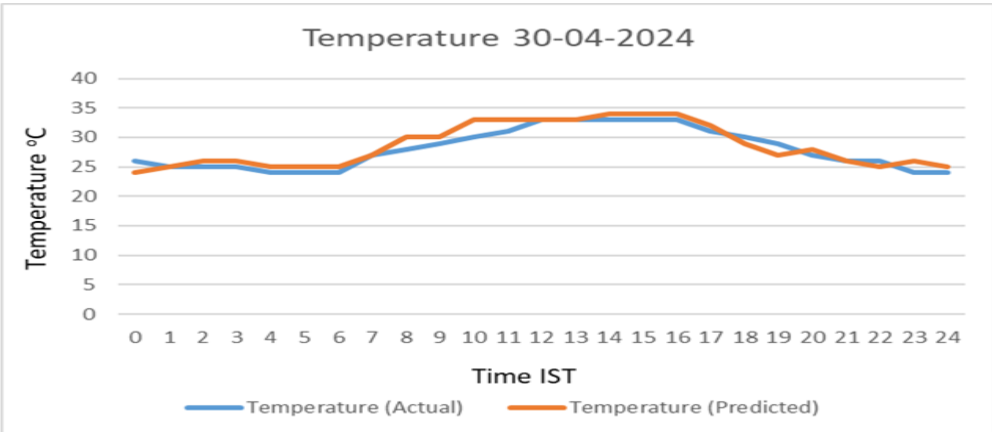


Fig. 4.49 Actual and Predicted Temperature

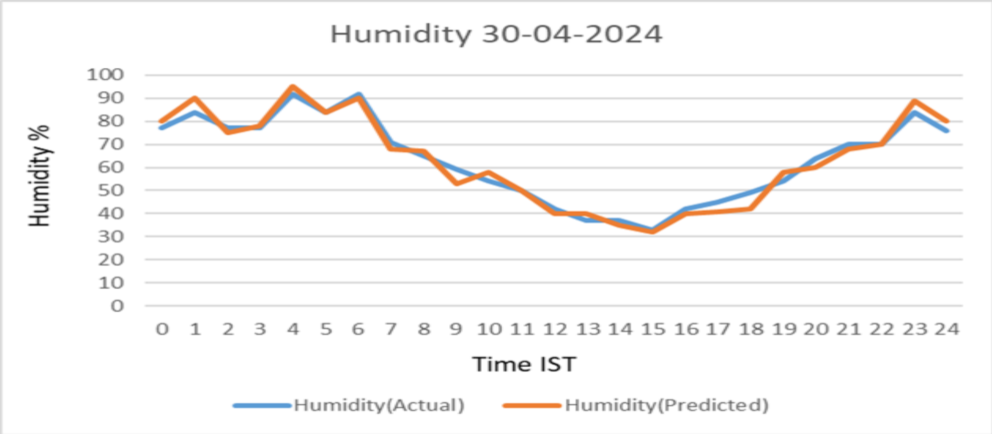


Fig. 4.50 Actual and Predicted Humidity

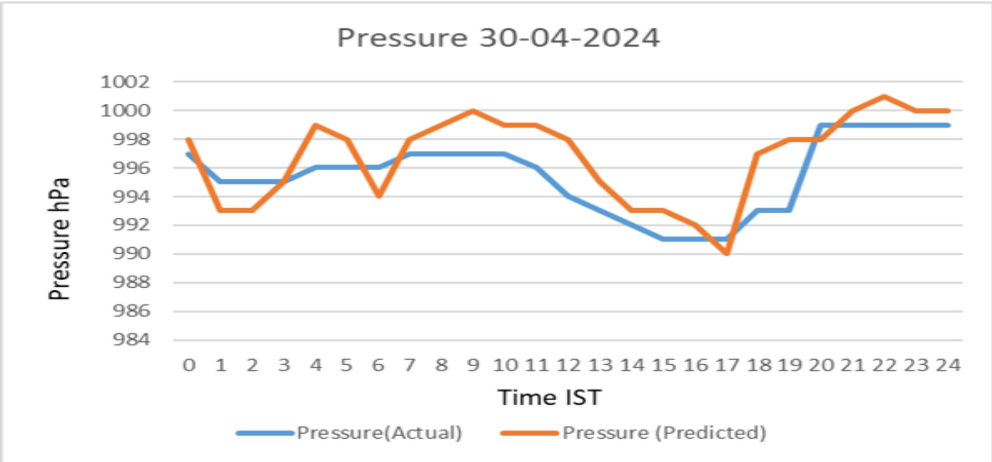


Fig. 4.51 Actual and Predicted Pressure

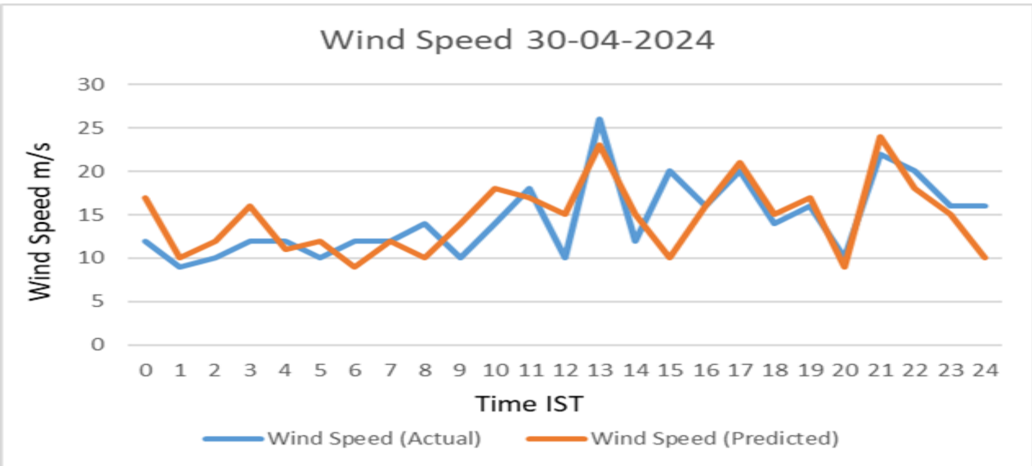


Fig. 4.52 Actual and Predicted Wind Speed

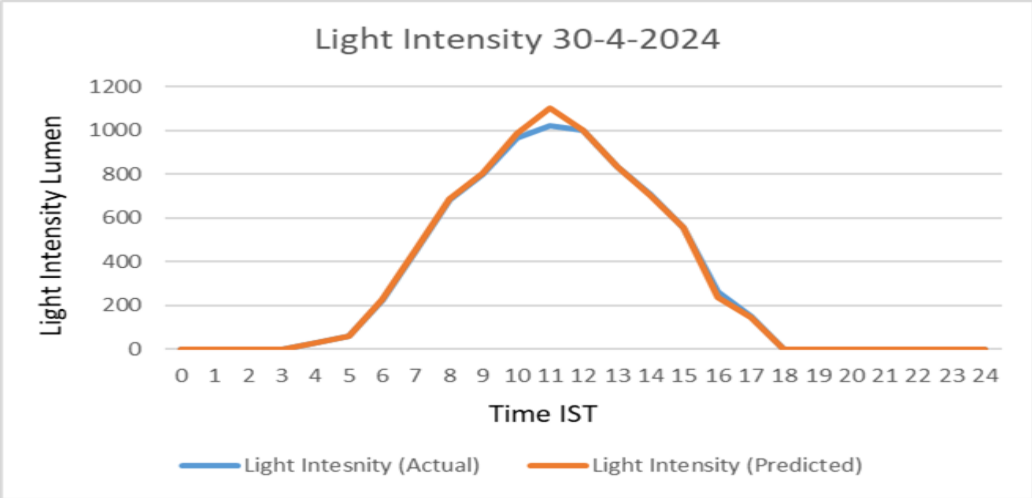


Fig. 4.53 Actual and Predicted Light Intensity

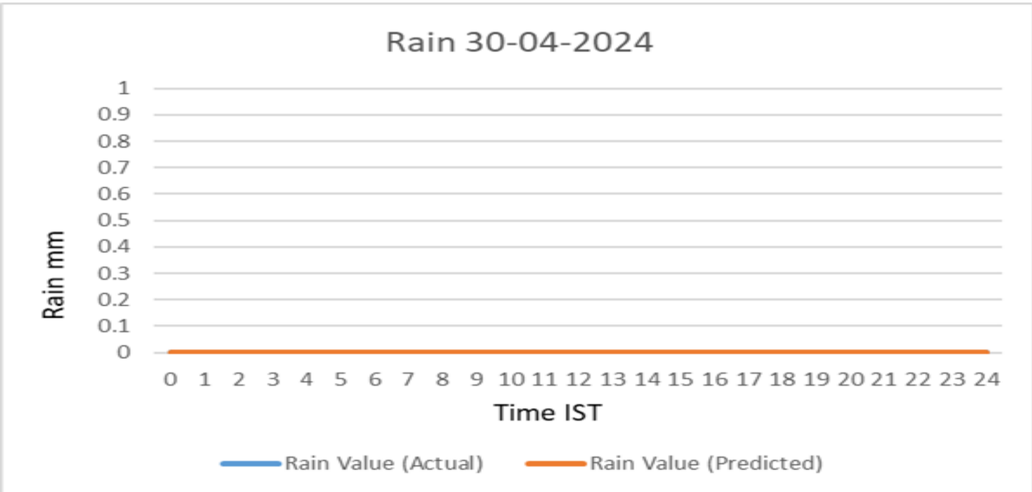


Fig. 4.54 Actual and Predicted Rain

Table 10: Predicted and actual data (01-05-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	01-05-2024	00:00:00	24	24	76	80	0	0	0	0	16	17	999	998
2	01-05-2024	01:00:00	24	25	76	90	0	0	0	0	12	10	994	993
3	01-05-2024	02:00:00	24	26	76	75	0	0	0	0	10	12	994	993
4	01-05-2024	03:00:00	23	26	83	78	0	0	0	0	10	16	993	995
5	01-05-2024	04:00:00	23	25	91	95	0	2	0	0	14	11	993	995
6	01-05-2024	05:00:00	23	25	91	84	148	150	0	0	16	12	994	998
7	01-05-2024	06:00:00	24	25	84	90	398	400	0	0	12	9	995	994
8	01-05-2024	07:00:00	25	27	77	74	701	702	0	0	12	12	995	996
9	01-05-2024	08:00:00	26	30	70	67	868	834	0	0	18	20	996	999
10	01-05-2024	09:00:00	27	30	64	60	775	765	0	0	16	14	996	1000
11	01-05-2024	10:00:00	29	33	59	58	1268	1199	0	0	20	18	995	999
12	01-05-2024	11:00:00	30	33	54	50	1270	1200	0	0	12	15	995	999
13	01-05-2024	12:00:00	32	33	46	40	1259	1234	0	0	14	15	993	994
14	01-05-2024	13:00:00	33	33	47	49	1269	1256	0	0	14	23	992	995
15	01-05-2024	14:00:00	34	34	43	40	1228	1298	0	0	12	15	991	993
16	01-05-2024	15:00:00	34	34	43	45	1165	1123	0	0	10	10	991	993
17	01-05-2024	16:00:00	34	34	38	40	1006	999	0	0	6	10	990	992
18	01-05-2024	17:00:00	34	32	43	41	638	654	0	0	4	5	990	990
19	01-05-2024	18:00:00	32	29	51	53	0	0	0	0	6	9	991	990
20	01-05-2024	19:00:00	31	27	61	58	0	0	0	0	0	2	992	995
21	01-05-2024	20:00:00	29	28	78	80	0	0	0	0	8	9	993	995
22	01-05-2024	21:00:00	28	26	85	87	0	0	0	0	6	7	993	992
23	01-05-2024	22:00:00	27	25	92	95	0	0	0	0	0	4	993	993
24	01-05-2024	23:00:00	26	26	92	89	0	0	0	0	6	8	993	994
25	01-05-2024	24:00:00	27	24	85	80	0	0	0	0	6	10	993	996

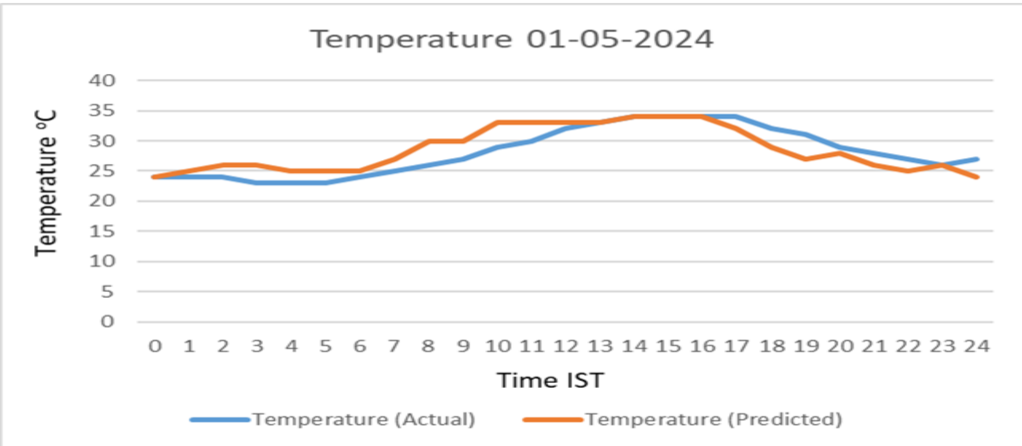


Fig. 4.55 Actual and Predicted Temperature

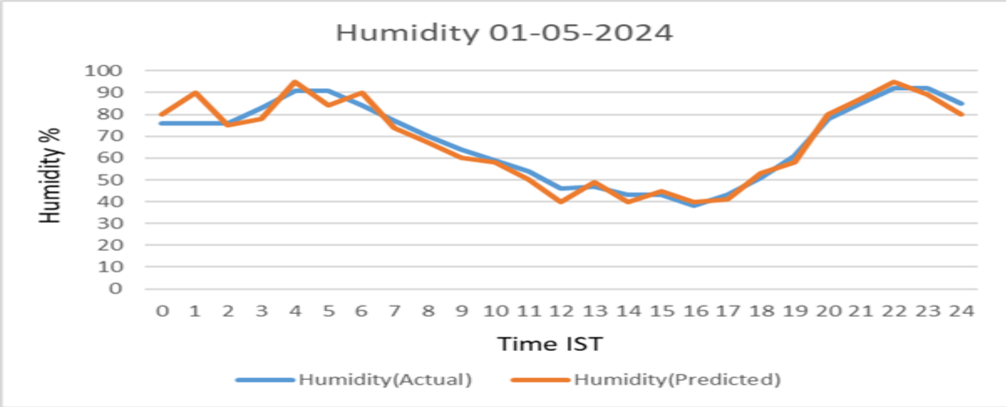


Fig. 4.56 Actual and Predicted Humidity

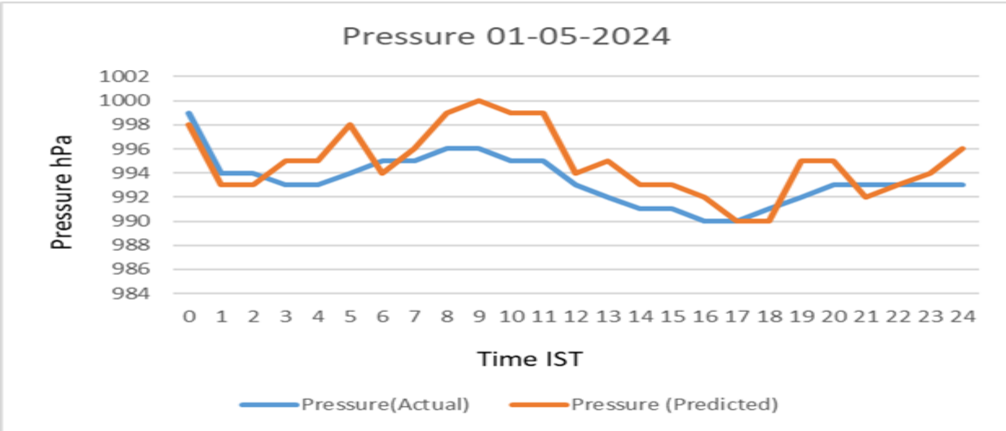


Fig. 4.57 Actual and Predicted Pressure

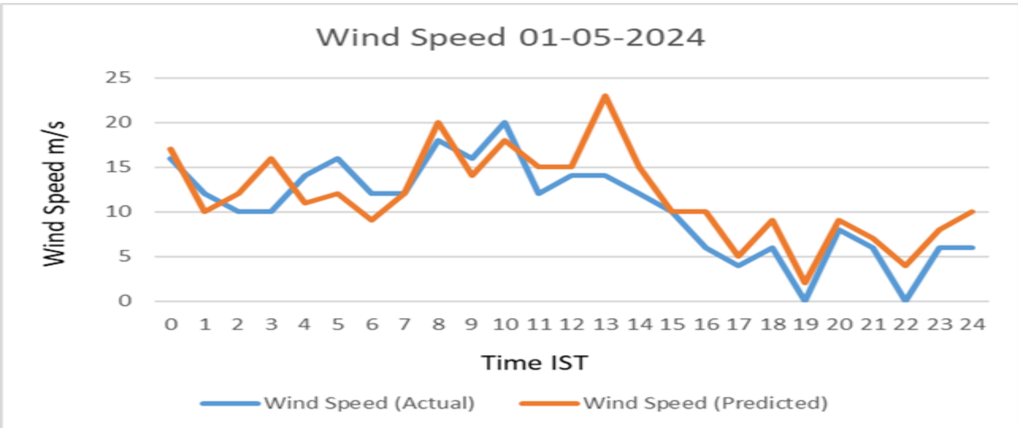


Fig. 4.58 Actual and Predicted Wind Speed

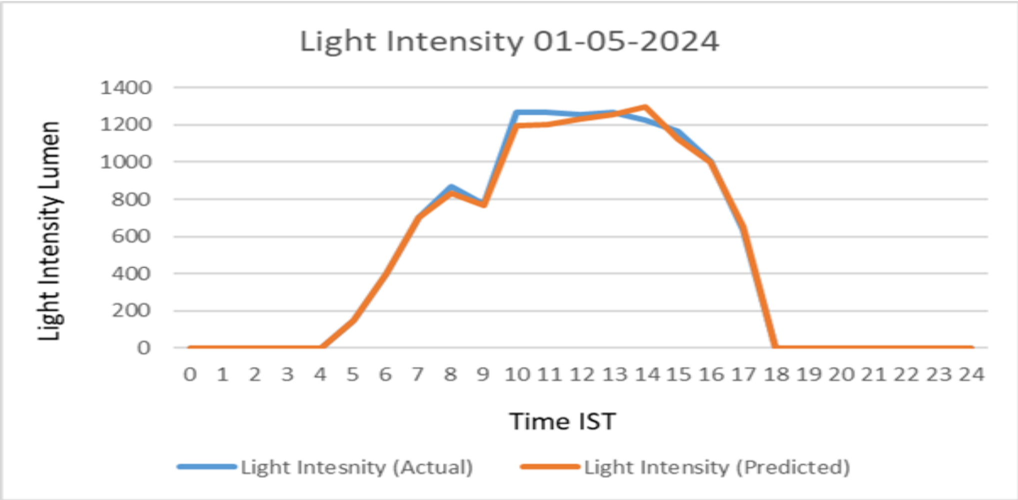


Fig. 4.59 Actual and Predicted Light Intensity

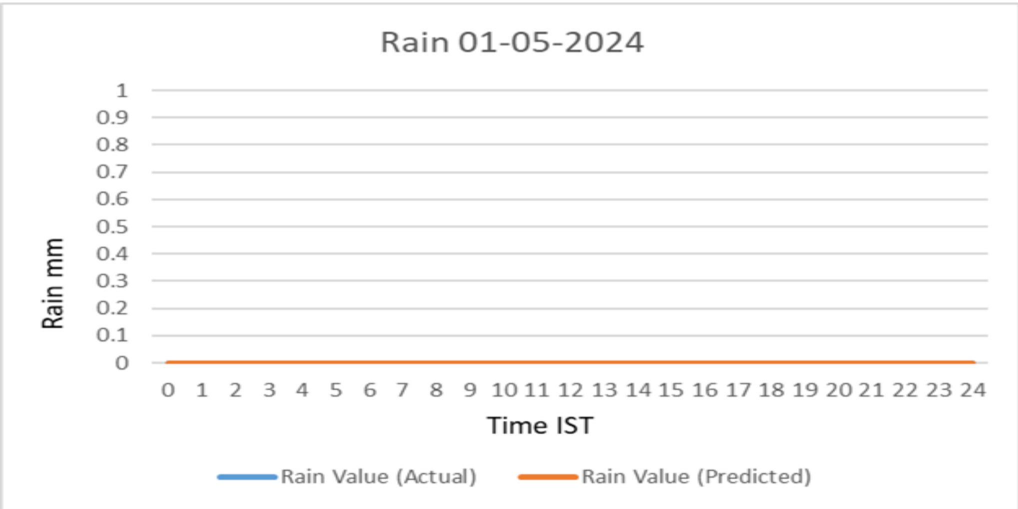


Fig. 4.60 Actual and Predicted Rain

Table 11: Predicted and actual data (02-05-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	02-04-2024	00:00:00	27	24	85	80	0	0	0	0	6	5	993	995
2	02-04-2024	01:00:00	26	25	92	90	0	0	0	0	0	2	992	993
3	02-04-2024	02:00:00	25	26	84	75	0	0	0	0	0	2	992	993
4	02-04-2024	03:00:00	24	26	84	80	0	0	0	0	0	0	992	995
5	02-04-2024	04:00:00	24	25	92	95	0	2	0	0	0	0	992	995
6	02-04-2024	05:00:00	25	25	70	78	148	150	0	0	8	12	992	991
7	02-04-2024	06:00:00	26	25	78	80	693	700	0	0	0	8	993	994
8	02-04-2024	07:00:00	29	27	59	65	946	950	0	0	6	7	994	996
9	02-04-2024	08:00:00	30	30	49	52	952	954	0	0	8	10	995	994
10	02-04-2024	09:00:00	30	30	49	53	1051	1060	0	0	0	2	995	996
11	02-04-2024	10:00:00	31	33	17	26	1100	1199	0	0	12	18	995	997
12	02-04-2024	11:00:00	33	33	13	19	1159	1200	0	0	20	15	994	998
13	02-04-2024	12:00:00	35	33	6	15	1209	1234	0	0	14	15	993	994
14	02-04-2024	13:00:00	36	33	4	16	890	900	0	0	10	14	992	990
15	02-04-2024	14:00:00	37	34	3	10	807	806	0	0	8	10	991	993
16	02-04-2024	15:00:00	37	34	6	12	397	400	0	0	16	10	990	993
17	02-04-2024	16:00:00	38	37	10	15	350	360	0	0	22	24	990	992
18	02-04-2024	17:00:00	36	35	10	20	235	260	0	0	12	15	991	990
19	02-04-2024	18:00:00	34	33	14	18	0	0	0	0	14	17	992	990
20	02-04-2024	19:00:00	32	31	36	25	0	0	0	0	20	22	993	995
21	02-04-2024	20:00:00	32	30	23	26	0	0	0	0	10	9	994	995
22	02-04-2024	21:00:00	31	29	26	30	0	0	0	0	20	22	995	992
23	02-04-2024	22:00:00	30	32	24	32	0	0	0	0	18	20	996	993
24	02-04-2024	23:00:00	29	26	23	35	0	0	0	0	17	19	996	994
25	02-04-2024	24:00:00	29	25	18	24	0	0	0	0	16	15	995	996

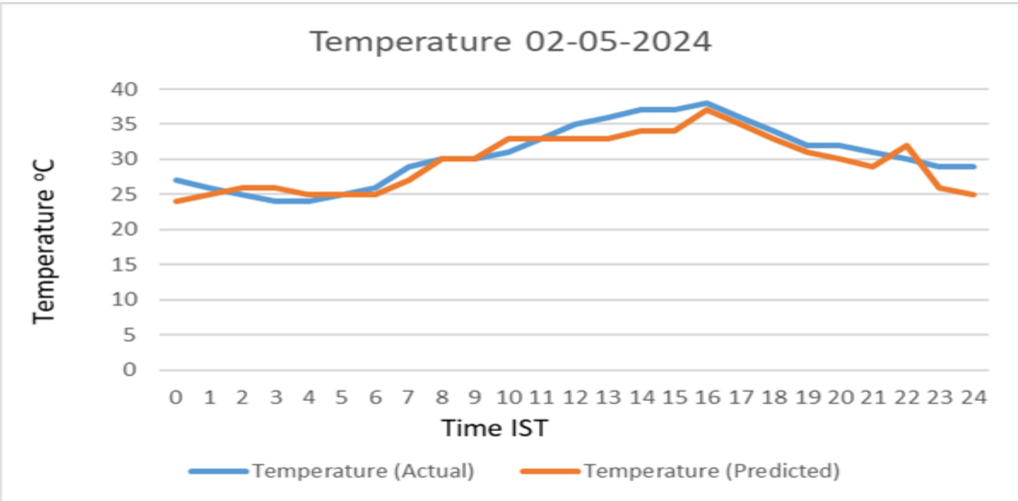


Fig. 4.61 Actual and Predicted Temperature

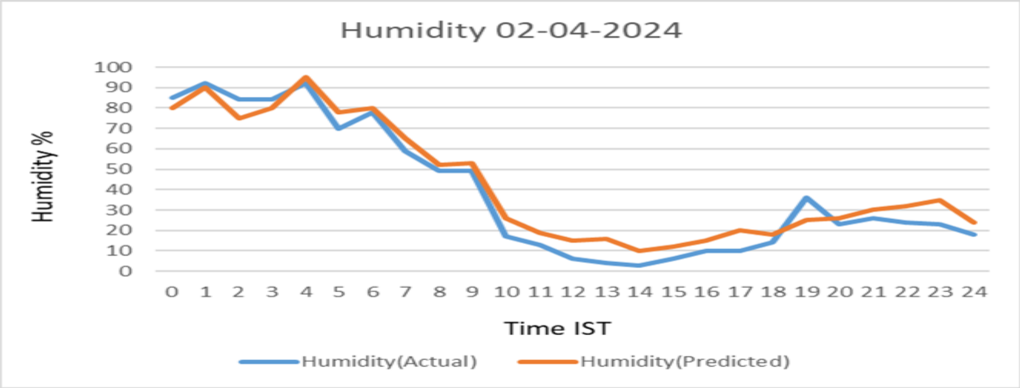


Fig. 4.62 Actual and Predicted Humidity

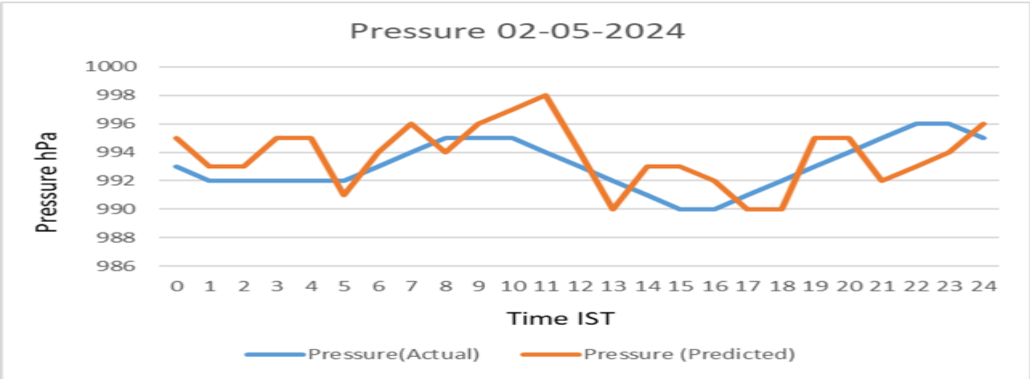


Fig. 4.63 Actual and Predicted Pressure

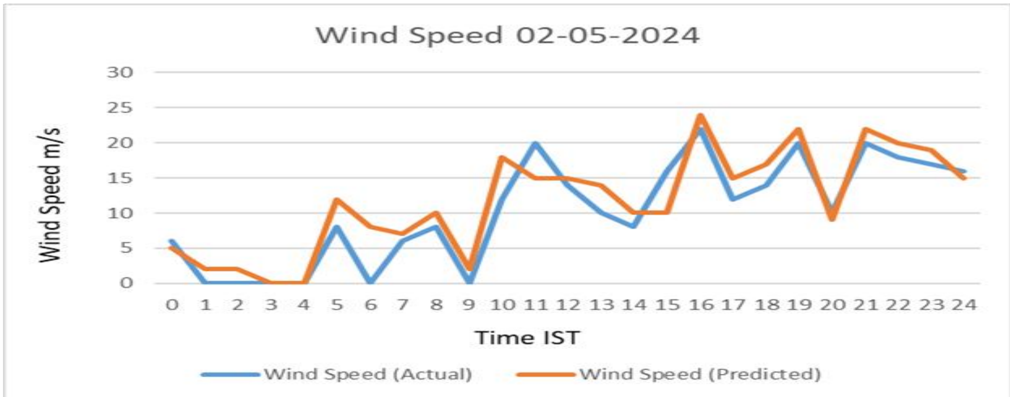


Fig. 4.64 Actual and Predicted Wind Speed

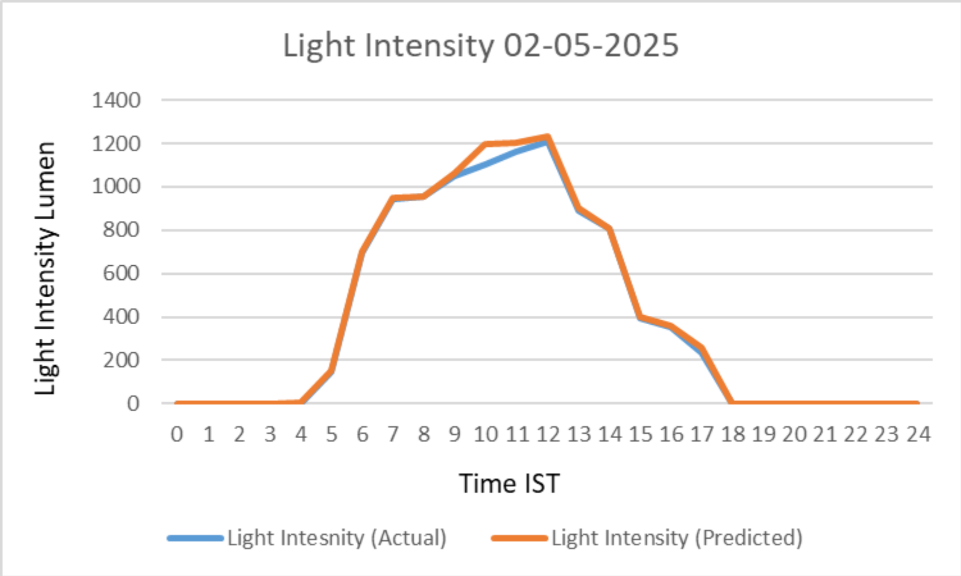


Fig. 4.65 Actual and Predicted Light Intensity

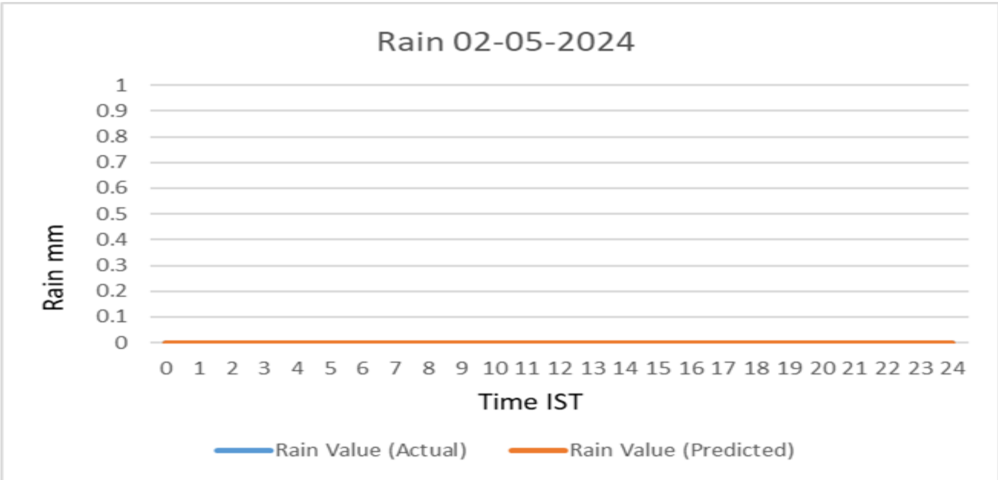


Fig. 4.66 Actual and Predicted Rain

Table 12: Predicted and actual data (03-05-2024)

Sl No.	Date	Time	Temperatu	Temperatu	Humidity(A	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(A	Pressure (
1	03-05-2024	00:00:00	29	30	18	21	0	0	0	0	16	10	995	995
2	03-05-2024	01:00:00	28	25	17	20	0	0	0	0	16	14	995	993
3	03-05-2024	02:00:00	27	26	24	26	0	0	0	0	15	13	995	993
4	03-05-2024	03:00:00	26	26	33	38	0	0	0	0	12	10	996	995
5	03-05-2024	04:00:00	26	25	39	40	0	2	0	0	10	8	997	995
6	03-05-2024	05:00:00	25	25	50	53	58	60	0	0	8	12	998	996
7	03-05-2024	06:00:00	25	25	56	52	223	250	0	0	8	8	999	1000
8	03-05-2024	07:00:00	26	27	51	50	452	467	0	0	14	15	1000	996
9	03-05-2024	08:00:00	27	30	52	51	682	670	0	0	14	10	1001	996
10	03-05-2024	09:00:00	28	30	53	60	797	821	0	0	16	18	1001	999
11	03-05-2024	10:00:00	31	33	35	37	964	1024	0	0	16	18	1001	997
12	03-05-2024	11:00:00	31	33	35	40	1020	1123	0	0	14	15	1001	998
13	03-05-2024	12:00:00	31	33	30	35	1002	1001	0	0	14	15	1000	997
14	03-05-2024	13:00:00	32	33	23	20	835	900	0	0	12	14	999	1000
15	03-05-2024	14:00:00	32	34	23	27	706	703	0	0	14	10	999	993
16	03-05-2024	15:00:00	32	34	19	25	555	500	0	0	16	17	993	993
17	03-05-2024	16:00:00	32	37	19	24	264	287	0	0	18	20	993	992
18	03-05-2024	17:00:00	31	35	21	26	124	129	0	0	16	15	994	992
19	03-05-2024	18:00:00	30	33	24	33	0	0	0	0	10	9	995	991
20	03-05-2024	19:00:00	29	31	27	30	0	0	0	0	0	5	995	995
21	03-05-2024	20:00:00	27	30	46	45	0	0	0	0	0	3	996	995
22	03-05-2024	21:00:00	26	29	63	61	0	0	0	0	0	8	997	998
23	03-05-2024	22:00:00	26	32	63	68	0	0	0	0	0	2	997	995
24	03-05-2024	23:00:00	25	26	63	65	0	0	0	0	10	15	997	994
25	03-05-2024	24:00:00	29	25	31	42	0	0	0	0	4	8	996	996

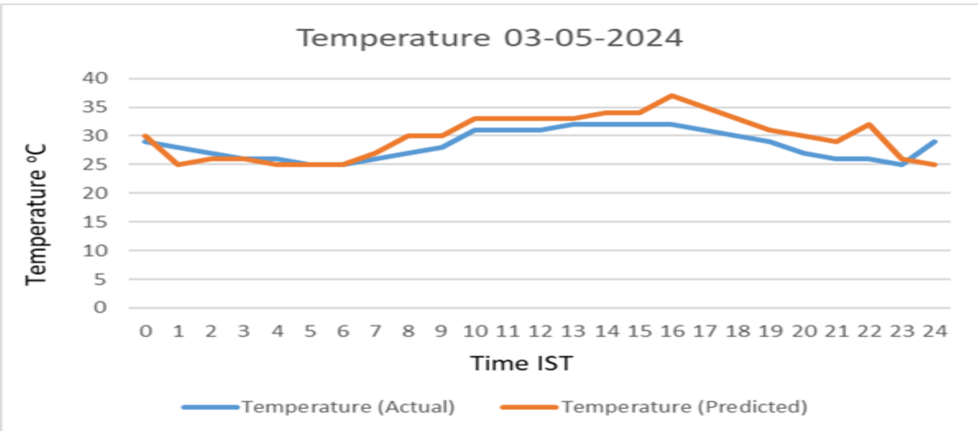


Fig. 4.67 Actual and Predicted Temperature

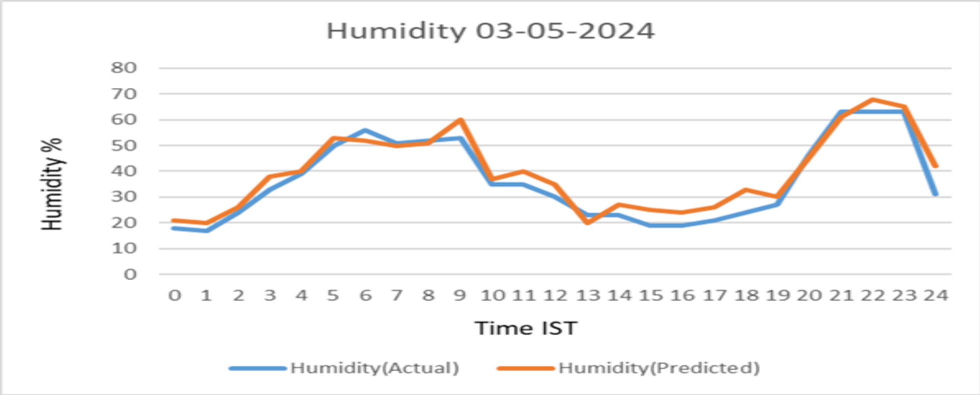


Fig. 4.68 Actual and Predicted Humidity

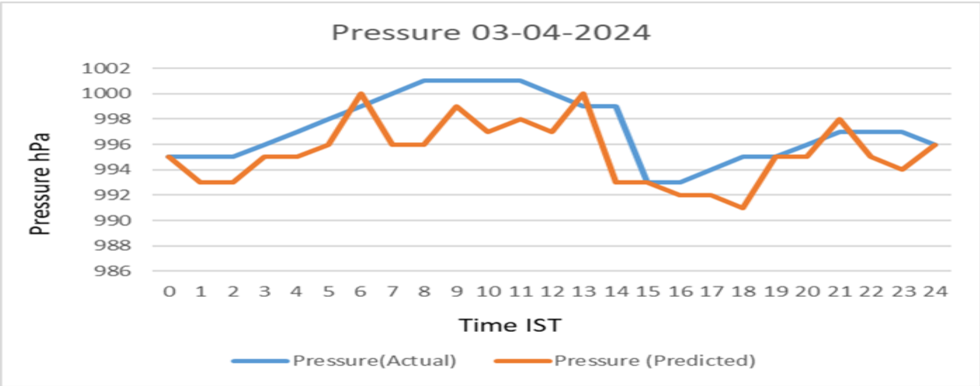


Fig. 4.69 Actual and Predicted Pressure

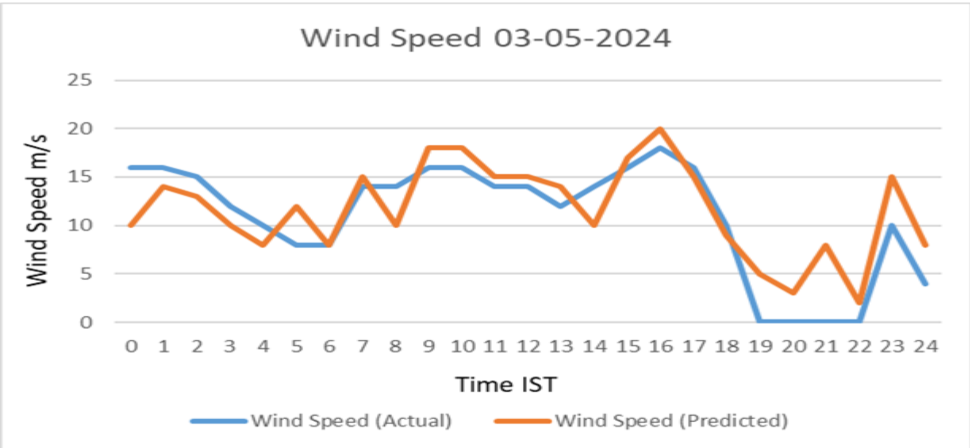


Fig. 4.70 Actual and Predicted Wind Speed

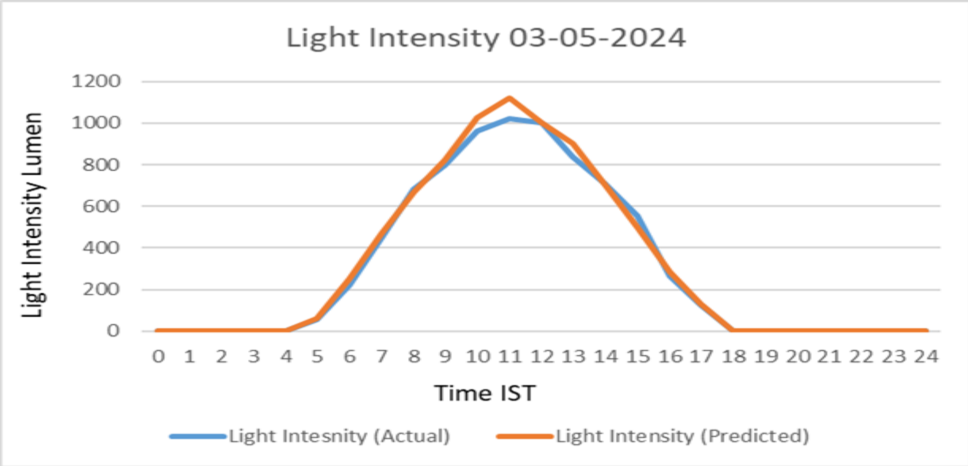


Fig. 4.71 Actual and Predicted Light Intensity

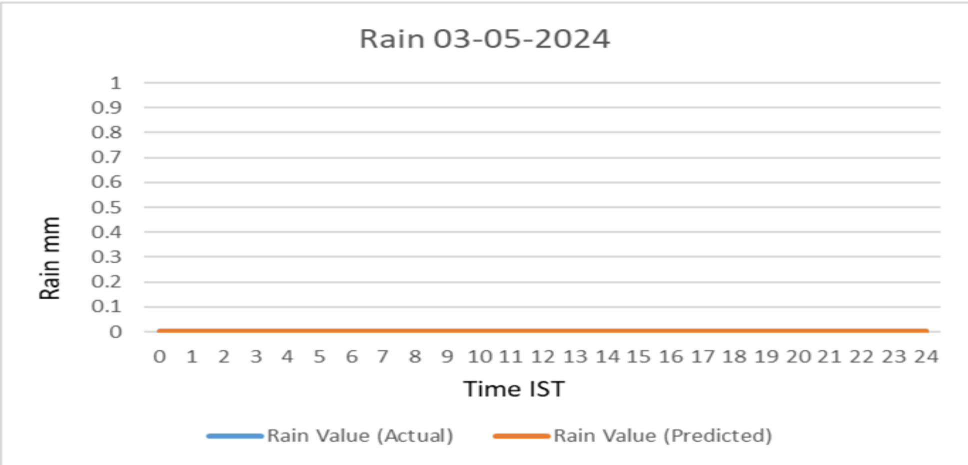


Fig. 4.72 Actual and Predicted Rain

Table 13: Predicted and actual data (04-05-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spee	Wind Spee	Pressure(	Pressure (
1	04-05-2024	00:00:00	29	24	37	40	0	0	0	0	4	9	996	999
2	04-05-2024	01:00:00	29	25	38	41	0	0	0	0	4	6	996	999
3	04-05-2024	02:00:00	28	26	41	45	0	0	0	0	4	8	998	999
4	04-05-2024	03:00:00	28	26	36	33	0	0	0	0	4	5	1000	1000
5	04-05-2024	04:00:00	29	25	36	40	0	0	0	0	6	8	1000	999
6	04-05-2024	05:00:00	29	25	38	40	554	600	0	0	8	10	1000	998
7	04-05-2024	06:00:00	30	26	38	40	678	628	0	0	10	7	1000	1000
8	04-05-2024	07:00:00	30	27	34	34	683	701	0	0	10	12	1002	1001
9	04-05-2024	08:00:00	31	28	34	35	789	824	0	0	12	10	1002	1000
10	04-05-2024	09:00:00	31	27	30	29	941	983	0	0	12	12	1002	1002
11	04-05-2024	10:00:00	31	27	30	25	976	985	0	0	14	12	1002	999
12	04-05-2024	11:00:00	32	33	30	26	947	954	0	0	14	6	1002	1003
13	04-05-2024	12:00:00	33	29	23	24	920	904	0	0	12	10	1001	1004
14	04-05-2024	13:00:00	34	35	20	23	635	623	0	0	12	9	1000	997
15	04-05-2024	14:00:00	32	29	22	22	555	532	0	0	8	11	999	996
16	04-05-2024	15:00:00	34	28	27	30	336	376	0	0	10	10	998	997
17	04-05-2024	16:00:00	33	27	18	25	121	150	0	0	8	4	997	996
18	04-05-2024	17:00:00	31	32	24	26	54	80	0	0	8	10	997	997
19	04-05-2024	18:00:00	30	29	30	31	0	0	0	0	4	8	998	997
20	04-05-2024	19:00:00	28	27	44	47	0	0	0	0	4	7	998	998
21	04-05-2024	20:00:00	28	28	53	55	0	0	0	0	4	9	998	998
22	04-05-2024	21:00:00	27	26	53	55	0	0	0	0	4	7	999	1000
23	04-05-2024	22:00:00	27	25	58	60	0	0	0	0	4	7	998	1001
24	04-05-2024	23:00:00	26	26	52	50	0	0	0	0	20	18	998	1000
25	04-05-2024	24:00:00	26	25	51	56	0	0	0	0	24	22	999	1002

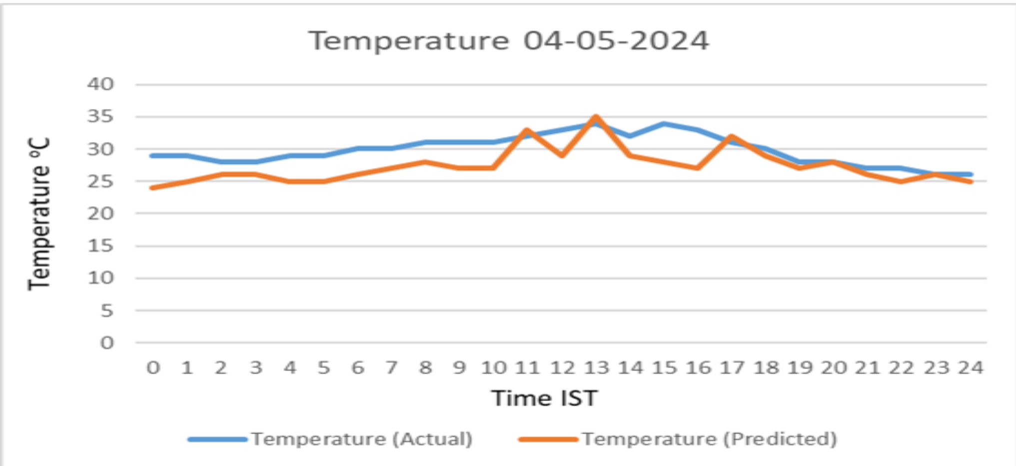


Fig. 4.73 Actual and Predicted Temperature

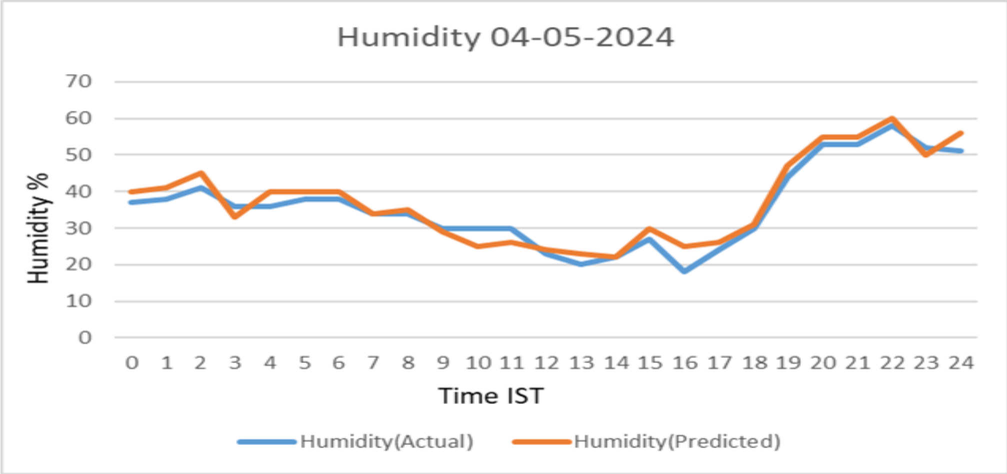


Fig. 4.74 Actual and Predicted Humidity

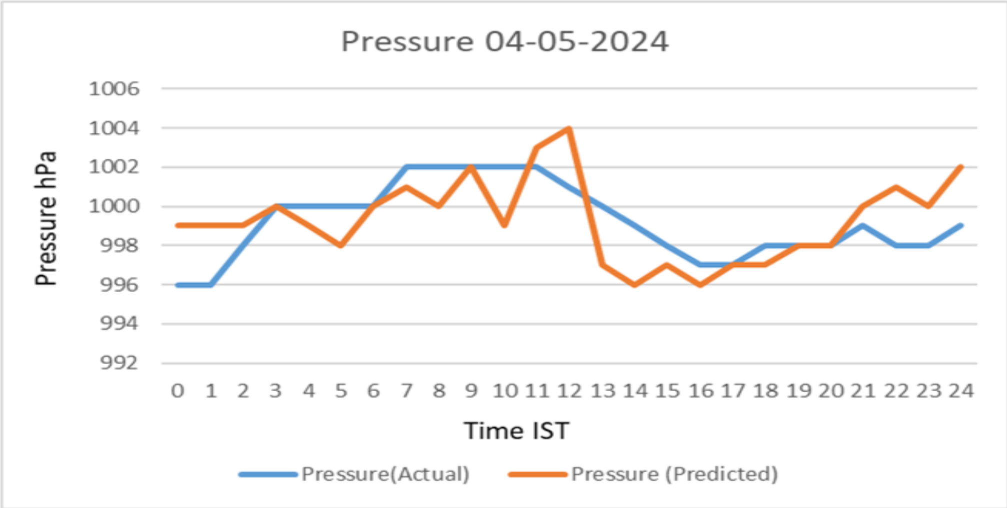


Fig. 4.75 Actual and Predicted Pressure

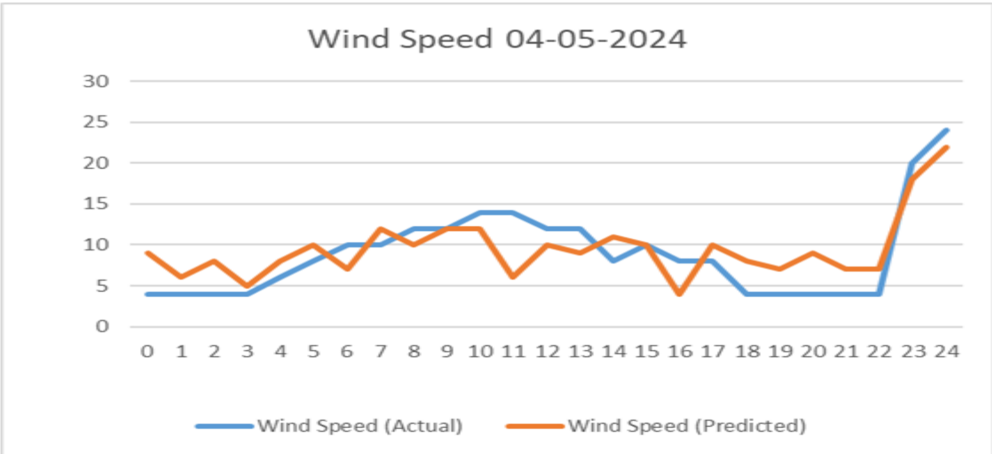


Fig. 4.76 Actual and Predicted Wind Speed

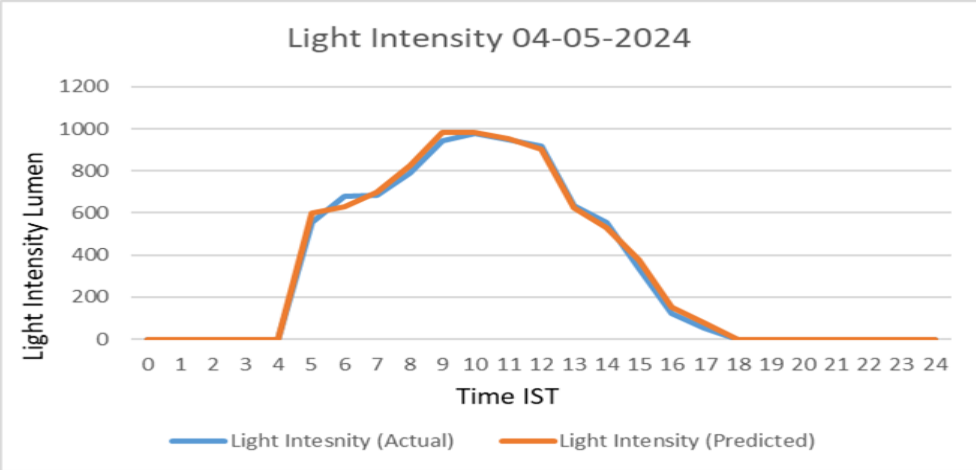


Fig. 4.77 Actual and Predicted Light Intensity

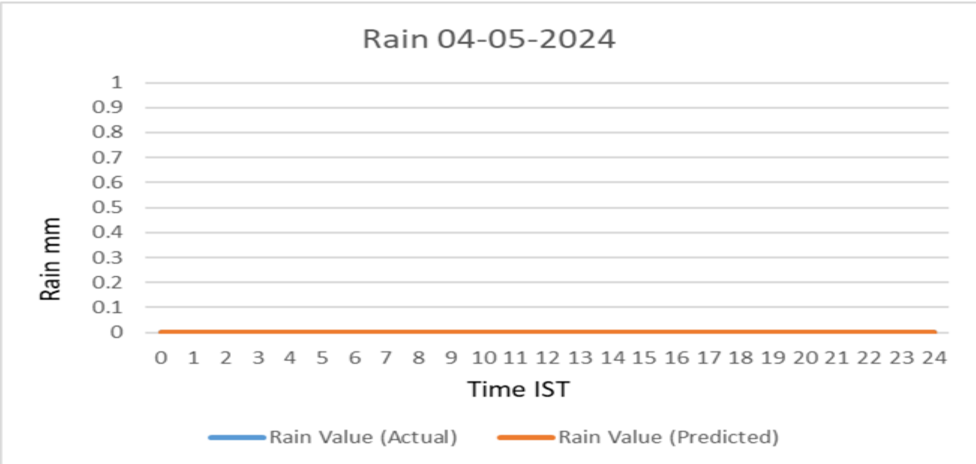


Fig. 4.78 Actual and Predicted Rain

Table 14: Predicted and actual data (05-05-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	05-05-2024	00:00:00	26	24	51	60	0	0	0	0	24	20	999	996
2	05-05-2024	01:00:00	26	25	57	65	0	0	0	0	12	10	997	999
3	05-05-2024	02:00:00	23	26	91	86	0	0	0	0	4	8	997	999
4	05-05-2024	03:00:00	23	26	91	87	0	0	0	0	0	5	998	1000
5	05-05-2024	04:00:00	23	25	91	95	0	0	0	0	4	8	998	999
6	05-05-2024	05:00:00	23	25	91	84	20	50	0	0	4	5	997	998
7	05-05-2024	06:00:00	24	25	84	80	316	520	0	0	0	3	997	1000
8	05-05-2024	07:00:00	25	27	84	88	661	650	0	0	14	12	998	1001
9	05-05-2024	08:00:00	26	30	70	71	746	730	0	0	14	10	999	1000
10	05-05-2024	09:00:00	27	30	71	65	745	768	0	0	16	12	1000	1002
11	05-05-2024	10:00:00	29	30	54	60	798	800	0	0	10	12	1000	999
12	05-05-2024	11:00:00	27	33	71	75	1365	1299	0	0	4	6	1000	999
13	05-05-2024	12:00:00	24	29	91	80	1251	1300	12.5	0	4	10	1000	998
14	05-05-2024	13:00:00	24	20	91	85	1091	1296	12.5	0	4	8	1000	997
15	05-05-2024	14:00:00	23	29	100	95	817	1023	14.5	0	14	11	1000	996
16	05-05-2024	15:00:00	22	28	91	86	542	785	29	0	10	10	999	997
17	05-05-2024	16:00:00	23	27	91	95	215	154	29	0	10	16	999	996
18	05-05-2024	17:00:00	22	25	100	91	101	98	30	0	10	10	999	997
19	05-05-2024	18:00:00	22	29	91	84	0	0	30	0	8	8	999	997
20	05-05-2024	19:00:00	22	27	91	82	0	0	30	0	16	18	1000	998
21	05-05-2024	20:00:00	22	28	91	90	0	0	30	0	14	15	1000	998
22	05-05-2024	21:00:00	22	26	91	87	0	0	30	0	10	7	1001	1000
23	05-05-2024	22:00:00	22	25	91	88	0	0	30	0	8	7	1001	1001
24	05-05-2024	23:00:00	22	26	91	84	0	0	30	0	4	6	1001	1000
25	05-05-2024	24:00:00	22	25	91	86	0	0	30	0	4	10	1001	1000

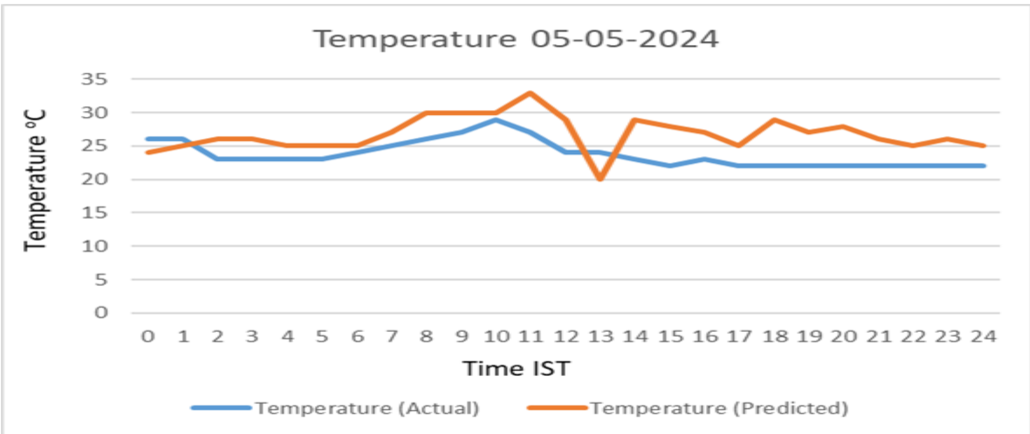


Fig. 4.79 Actual and Predicted Temperature

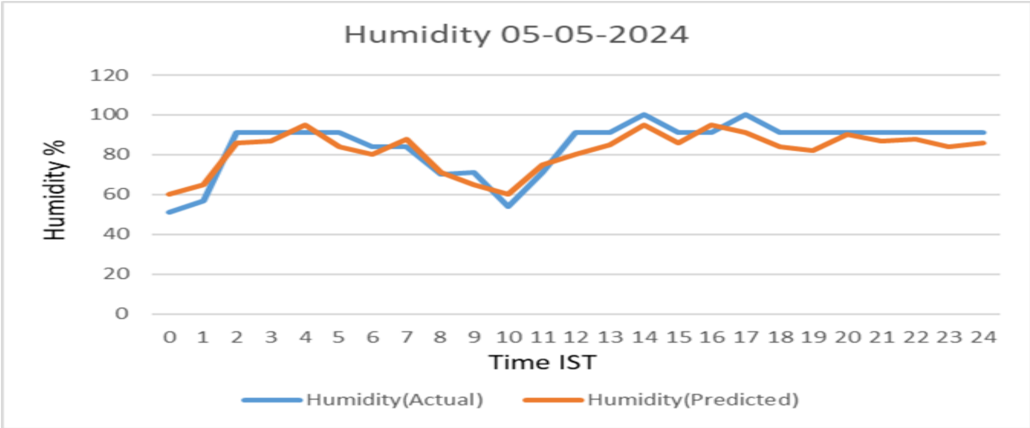


Fig. 4.80 Actual and Predicted Humidity

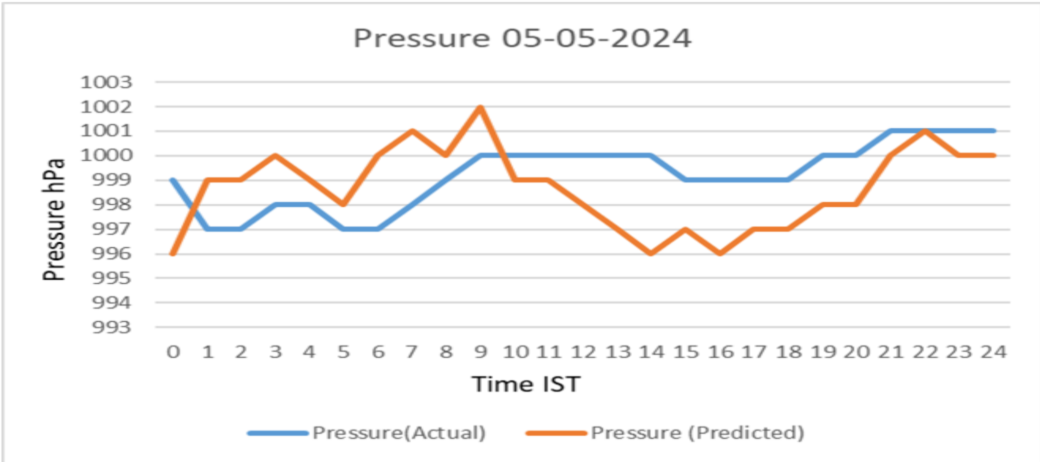


Fig. 4.81 Actual and Predicted Pressure

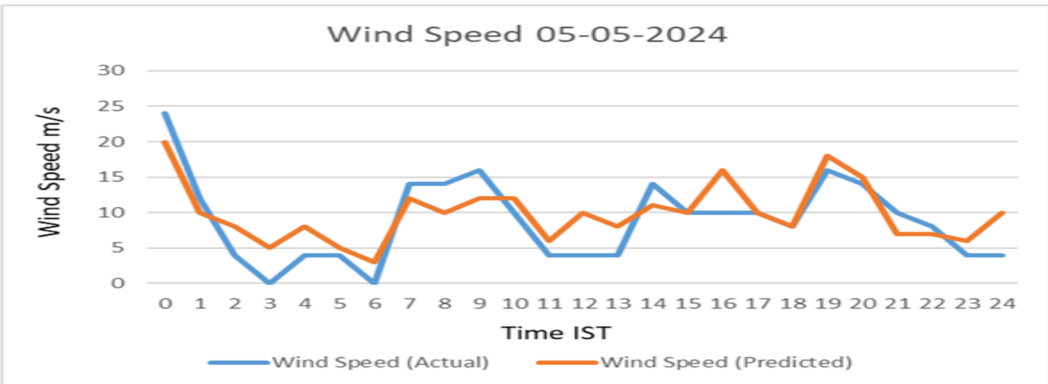


Fig. 4.82 Actual and Predicted Wind Speed

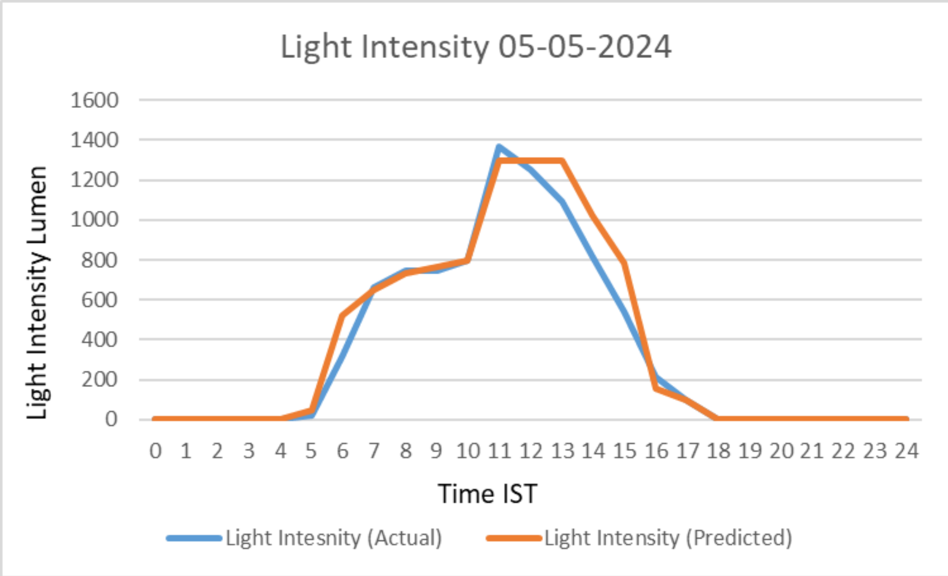


Fig. 4.83 Actual and Predicted Light Intensity

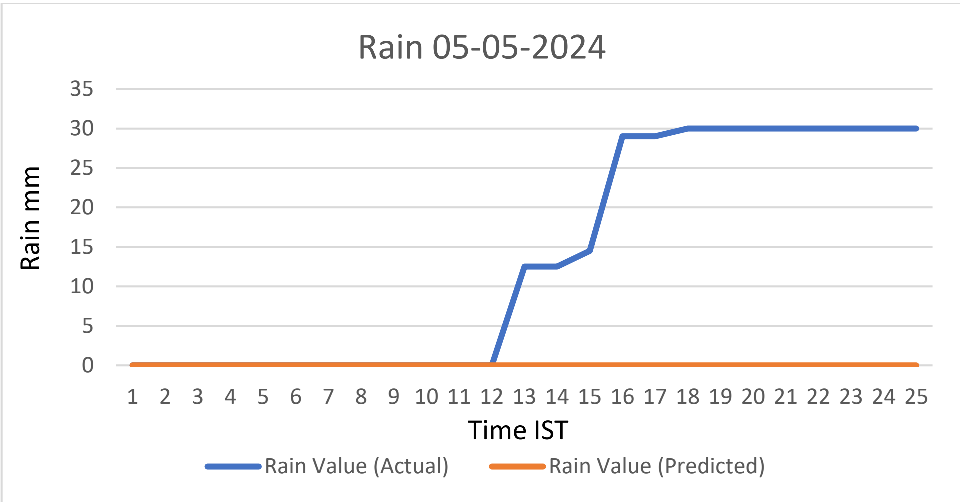


Fig. 4.84 Actual and Predicted Rain

Table 15: Predicted and actual data (06-05-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Valu	Rain Valu	Wind Spe	Wind Spe	Pressure(	Pressure (
1	06-05-24	00:00:00	22	24	91	95	0	0	0	0.6	4	9	1001	999
2	06-05-24	01:00:00	22	25	91	93	0	0	0	0.7	4	6	1001	999
3	06-05-24	02:00:00	21	26	91	86	0	0	31.5	0.8	4	8	1001	999
4	06-05-24	03:00:00	22	26	91	87	0	0	33	4	14	5	1002	1000
5	06-05-24	04:00:00	22	25	91	95	0	0	36	10	14	8	1004	999
6	06-05-24	05:00:00	22	25	91	84	0	50	40.5	12	14	10	1002	998
7	06-05-24	06:00:00	22	25	91	80	234	300	43.5	3	0	3	1003	1000
8	06-05-24	07:00:00	22	23	91	88	108	120	43.5	5	14	12	1004	1001
9	06-05-24	08:00:00	22	28	91	89	54	60	43.5	7	10	10	1005	1000
10	06-05-24	09:00:00	22	27	91	83	828	768	44	10	12	12	1005	1002
11	06-05-24	10:00:00	23	25	91	85	521	598	0	0	8	12	1005	999
12	06-05-24	11:00:00	23	25	91	81	500	497	0	0	10	6	1005	1006
13	06-05-24	12:00:00	24	29	84	80	1098	1128	0	11.3	18	10	1004	1005
14	06-05-24	13:00:00	23	20	91	85	246	300	0	12.5	14	9	1003	997
15	06-05-24	14:00:00	24	29	76	80	452	489	0	13.6	10	11	1003	996
16	06-05-24	15:00:00	23	28	91	86	541	589	0	27.5	10	10	1002	997
17	06-05-24	16:00:00	24	27	84	95	873	900	0	24.6	12	16	1002	996
18	06-05-24	17:00:00	24	25	76	71	491	521	0	0.9	14	10	1002	997
19	06-05-24	18:00:00	23	29	83	84	0	0	0	1.2	8	8	1003	997
20	06-05-24	19:00:00	24	27	76	80	0	0	0	0.4	10	14	1003	998
21	06-05-24	20:00:00	23	28	83	90	0	0	0.5	2.3	12	15	1004	998
22	06-05-24	21:00:00	23	26	91	87	0	0	2.5	4.5	6	7	1004	1000
23	06-05-24	22:00:00	23	25	91	88	0	0	0	6.9	12	7	1004	1001
24	06-05-24	23:00:00	22	26	91	84	0	0	0	3.6	14	6	1004	1000
25	06-05-24	24:00:00	22	25	91	86	0	0	0	7.5	8	10	1005	1005

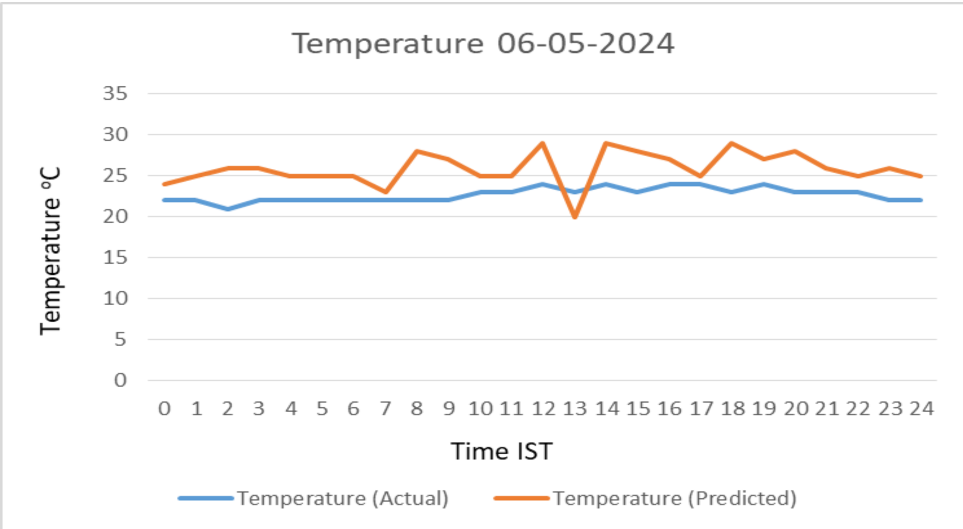


Fig. 4.85 Actual and Predicted Temperature

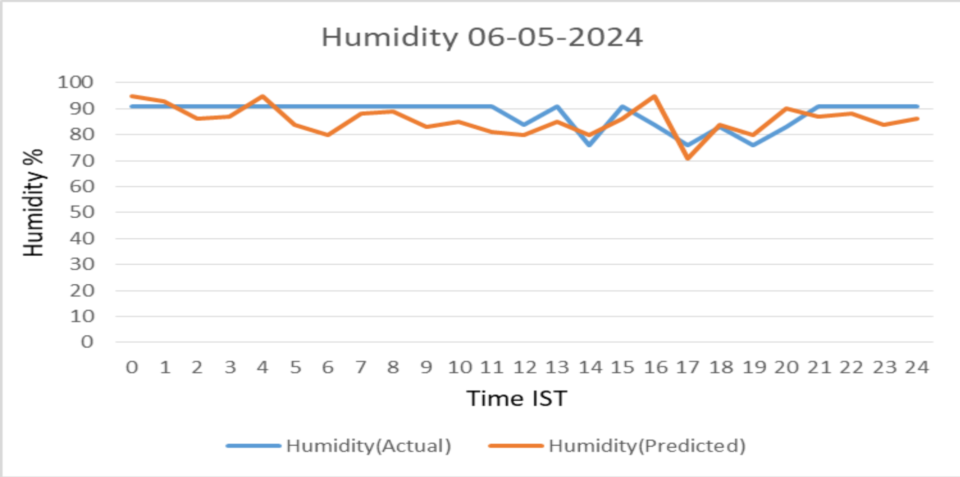


Fig. 4.86 Actual and Predicted Humidity

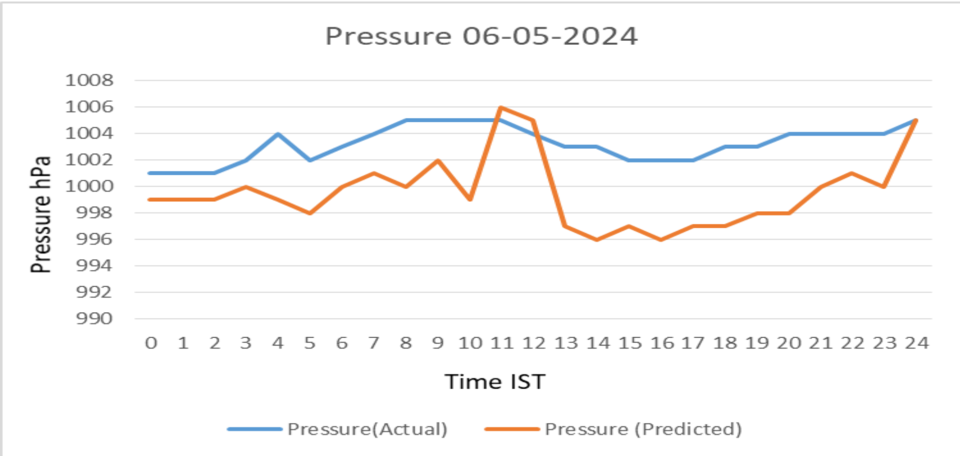


Fig. 4.87 Actual and Predicted Pressure

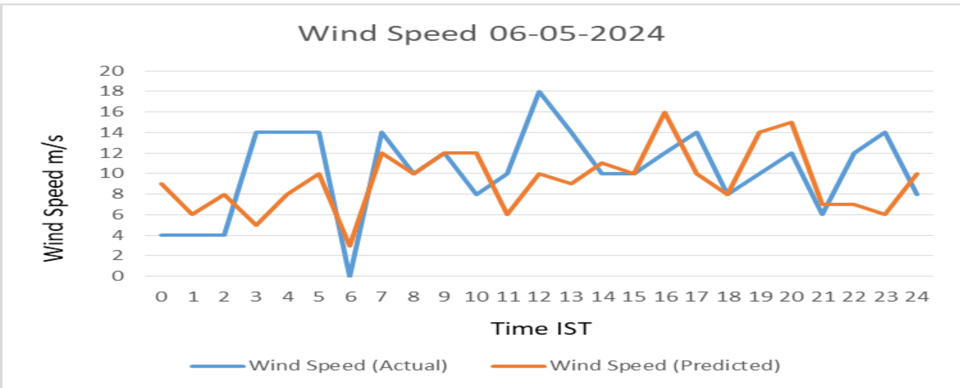


Fig. 4.88 Actual and Predicted Wind Speed

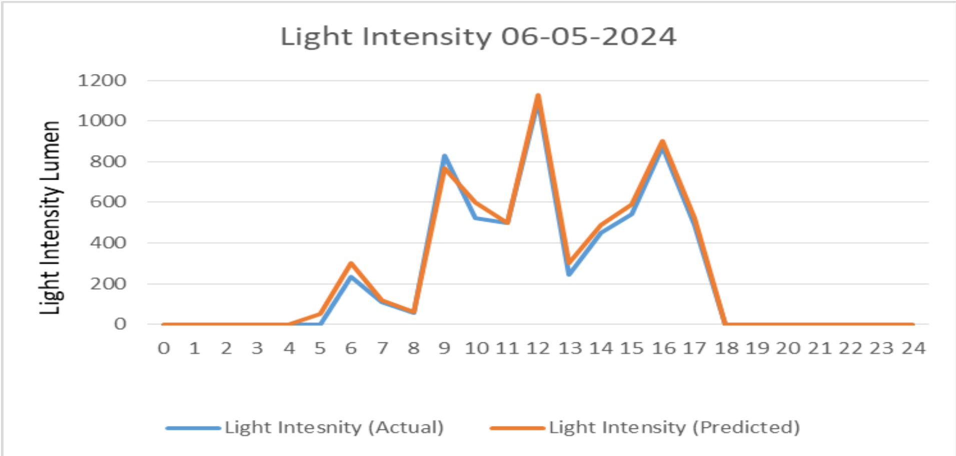


Fig. 4.89 Actual and Predicted Light Intensity

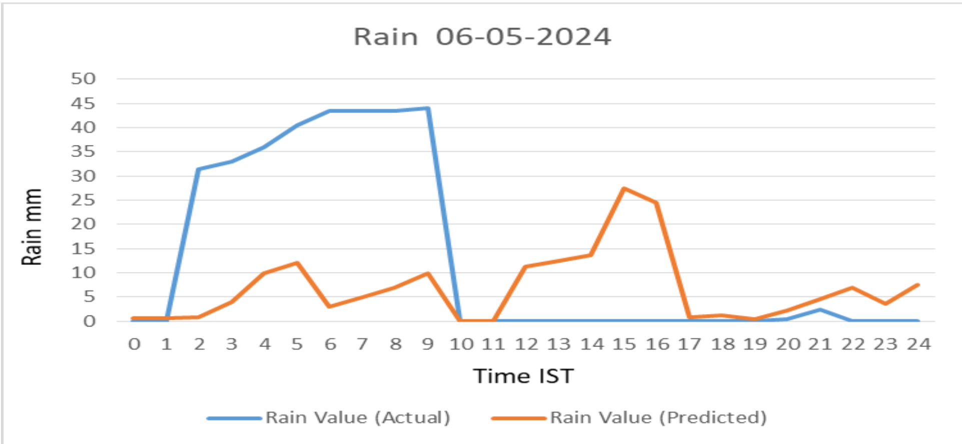


Fig. 4.90 Actual and Predicted Rain

Table 16: Predicted and actual data (01-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	01-06-24	00:00:00	28	24	100	98	0	0	0	0.5	12	20	998	996
2	01-06-24	01:00:00	28	25	100	98	0	0	0	0.5	10	10	998	999
3	01-06-24	02:00:00	28	26	100	99	0	0	0	0.5	10	8	998	999
4	01-06-24	03:00:00	28	26	100	97	0	0	0	0.7	8	5	999	1000
5	01-06-24	04:00:00	29	25	100	95	0	0	0	0.8	8	8	999	999
6	01-06-24	05:00:00	31	30	92	90	20	50	0	0.9	6	5	999	998
7	01-06-24	06:00:00	30	31	92	88	316	520	0	1	6	3	1000	1000
8	01-06-24	07:00:00	32	27	92	88	661	650	0	1	6	5	1000	1001
9	01-06-24	08:00:00	32	30	67	71	746	730	0	1	8	10	1000	1000
10	01-06-24	09:00:00	33	30	67	65	745	768	0	0.3	4	7	1000	1002
11	01-06-24	10:00:00	33	31	62	60	798	800	0	0.2	10	12	999	999
12	01-06-24	11:00:00	34	33	68	70	1365	1299	0	0.6	8	6	999	999
13	01-06-24	12:00:00	35	34	58	61	1251	1300	0	0.8	14	10	998	998
14	01-06-24	13:00:00	35	34	53	57	1091	1296	0	0.15	8	8	997	997
15	01-06-24	14:00:00	34	35	58	57	817	1023	0	0.2	6	7	997	996
16	01-06-24	15:00:00	34	35	53	50	542	785	0	0.28	12	10	996	997
17	01-06-24	16:00:00	34	33	58	55	215	154	0	0.36	8	7	996	996
18	01-06-24	17:00:00	33	33	68	70	101	98	0	0.39	4	5	996	997
19	01-06-24	18:00:00	31	29	69	71	0	0	0	0.4	0	4	996	997
20	01-06-24	19:00:00	29	27	33	40	0	0	0.34	0.41	4	7	997	998
21	01-06-24	20:00:00	27	28	100	93	0	0	0.68	0.5	0	4	999	998
22	01-06-24	21:00:00	26	26	92	87	0	0	0.92	0.69	30	15	999	1000
23	01-06-24	22:00:00	27	25	92	88	0	0	1	0.7	36	29	999	1001
24	01-06-24	23:00:00	27	26	92	89	0	0	1	0.6	14	15	999	1000
25	01-06-24	24:00:00	27	25	92	90	0	0	1	0.8	8	10	999	1000

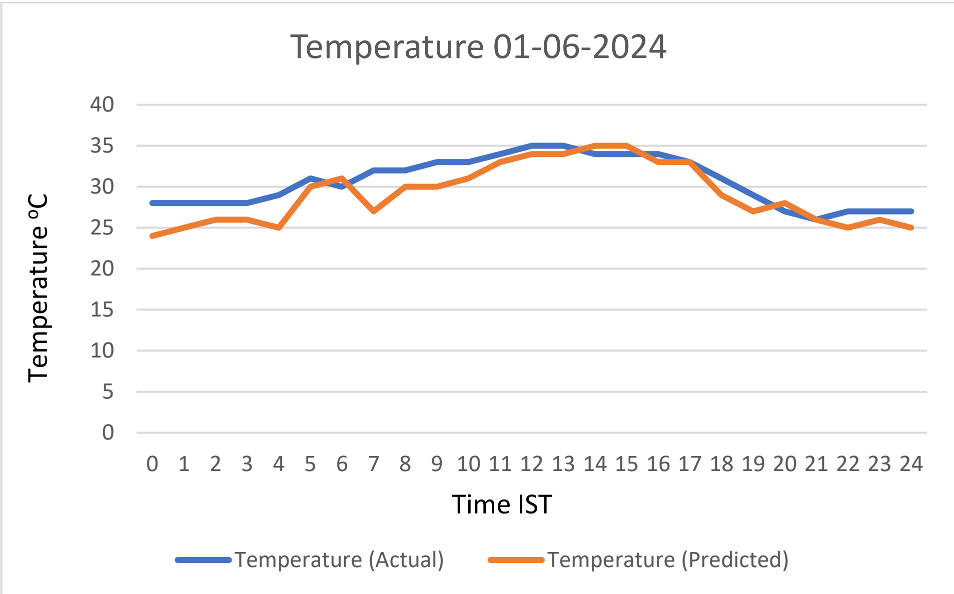


Fig. 4.91 Actual and Predicted Temperature

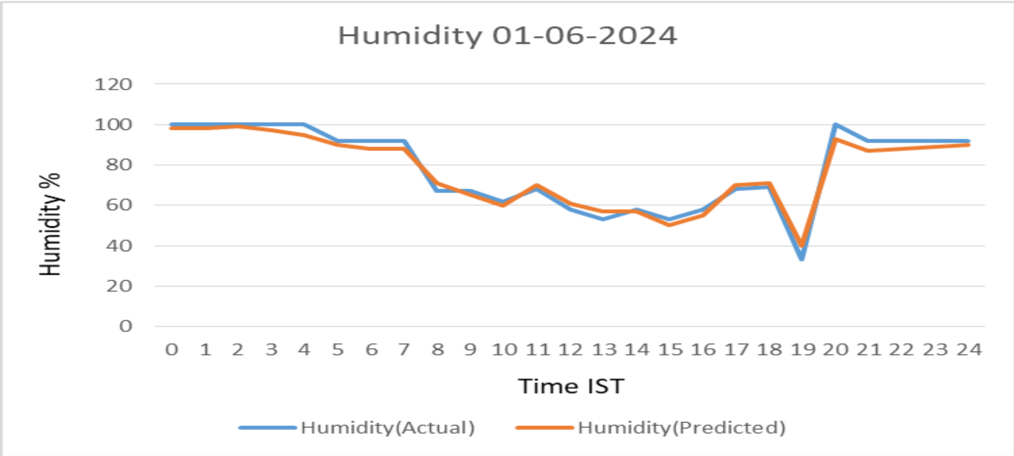


Fig. 4.92 Actual and Predicted Humidity

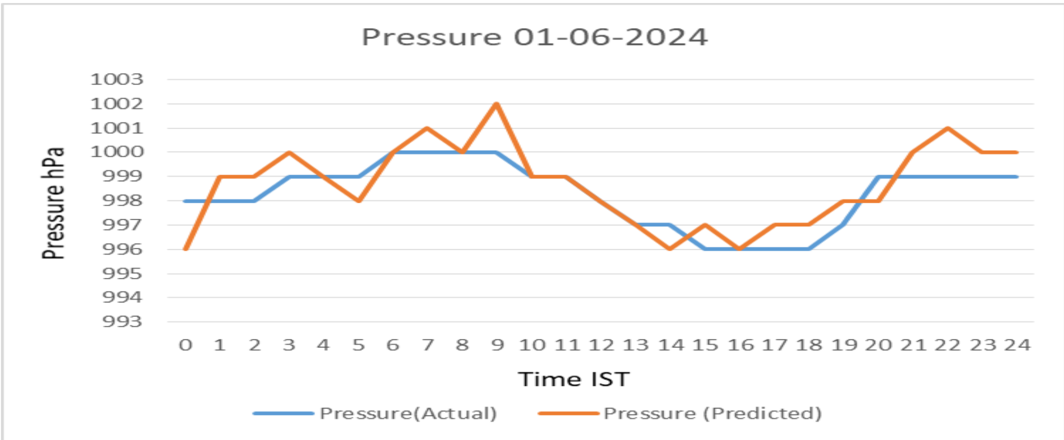


Fig. 4.93 Actual and Predicted Pressure

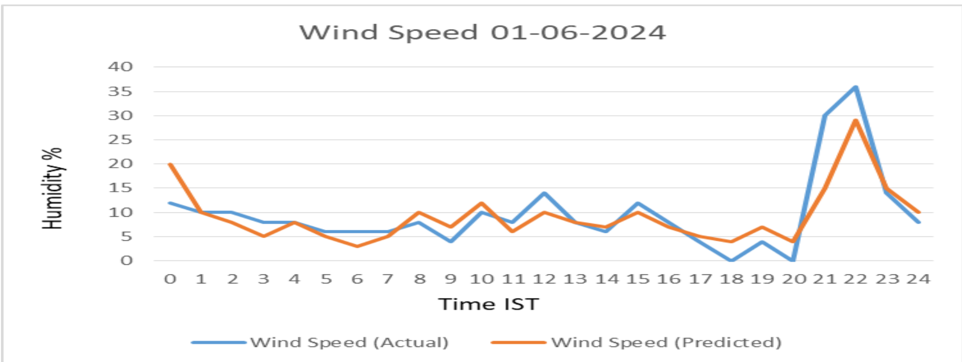


Fig. 4.94 Actual and Predicted Wind Speed

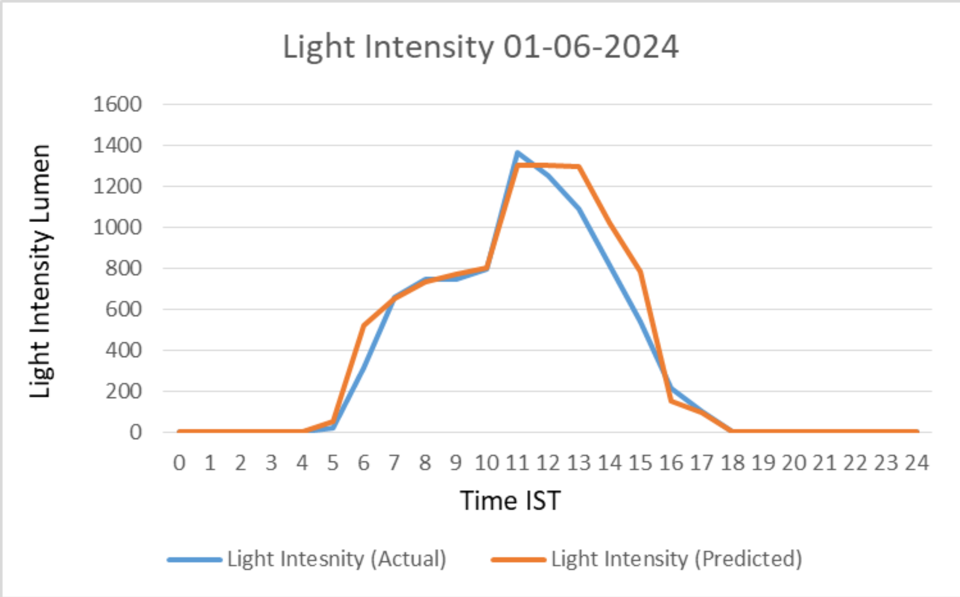


Fig. 4.95 Actual and Predicted Light Intensity

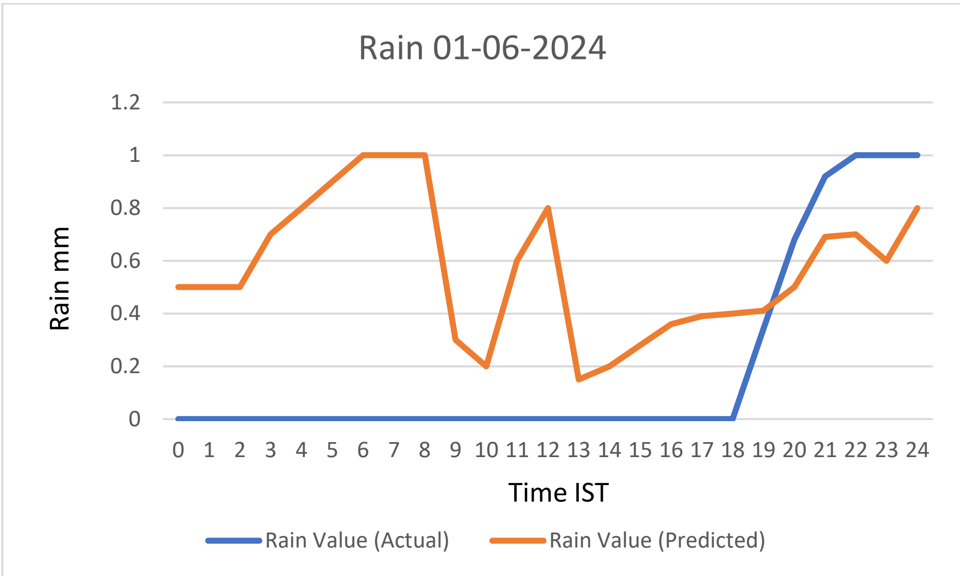


Fig. 4.96 Actual and Predicted Rain

Table 17: Predicted and actual data (02-06-2024)

S.No	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	02-06-24	00:00:00	27	24	92	86	0	0	0	0.5	8	10	999	998
2	02-06-24	01:00:00	27	25	92	90	0	0	0	0.5	12	10	999	997
3	02-06-24	02:00:00	26	26	92	89	0	0	0	0.5	12	10	999	998
4	02-06-24	03:00:00	26	26	100	95	0	1	0	0.7	12	10	1000	997
5	02-06-24	04:00:00	27	25	92	95	541	500	0	0.8	6	8	999	997
6	02-06-24	05:00:00	27	25	92	94	845	837	0	0.9	6	8	997	998
7	02-06-24	06:00:00	26	25	92	90	1021	999	0	1	4	4	1001	1000
8	02-06-24	07:00:00	29	27	100	89	1226	1101	0	1	8	8	1001	1001
9	02-06-24	08:00:00	30	24	72	80	1330	1308	0	1	8	7	1001	999
10	02-06-24	09:00:00	31	25	66	68	1380	1350	0	1.54	10	7	1001	998
11	02-06-24	10:00:00	32	30	67	70	1356	1380	0	2.36	10	4	1001	997
12	02-06-24	11:00:00	32	31	62	58	1366	1360	0	3.25	8	9	1000	998
13	02-06-24	12:00:00	33	33	62	55	1342	1350	0	4.28	16	11	999	997
14	02-06-24	13:00:00	33	35	57	50	1287	1299	0	5.28	8	9	999	996
15	02-06-24	14:00:00	34	34	57	54	1204	1210	0	6.12	14	11	998	996
16	02-06-24	15:00:00	32	36	63	64	1033	1101	0	7.22	10	8	997	994
17	02-06-24	16:00:00	33	33	62	63	932	950	0	9.36	14	10	997	993
18	02-06-24	17:00:00	32	34	62	37	490	457	0	11.63	12	14	997	995
19	02-06-24	18:00:00	31	29	73	76	0	0	0	15.28	8	10	998	992
20	02-06-24	19:00:00	31	30	79	72	0	0	0	19.25	8	9	998	995
21	02-06-24	20:00:00	30	29	79	75	0	0	0	20.36	12	10	999	998
22	02-06-24	21:00:00	30	26	85	79	0	0	0	21.85	10	8	999	996
23	02-06-24	22:00:00	29	26	85	78	0	0	0	22.38	12	15	999	996
24	02-06-24	23:00:00	28	25	92	87	0	0	3	22.74	14	16	999	995
25	02-06-24	24:00:00	27	24	100	89	0	0	19	22.98	14	17	998	995

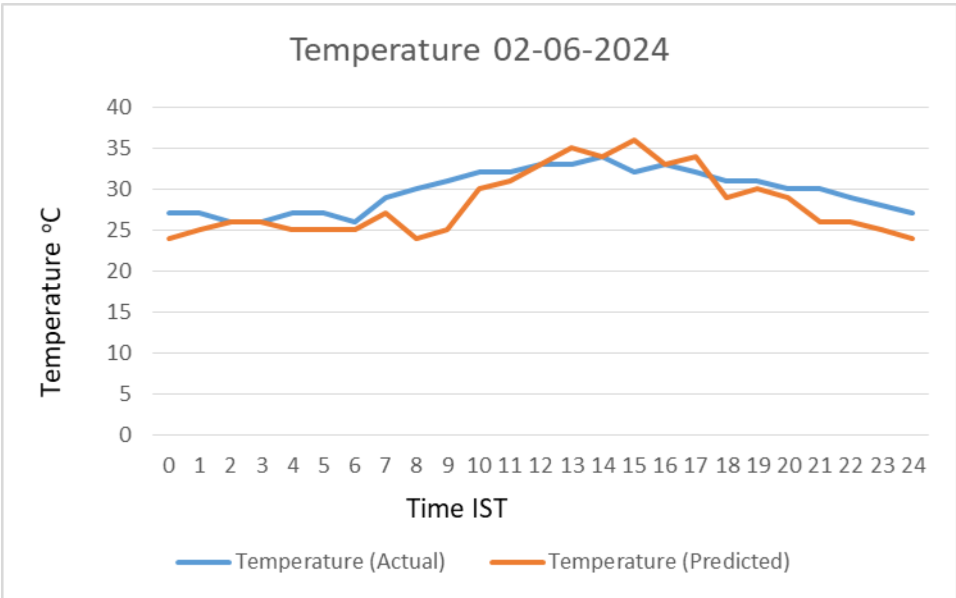


Fig. 4.97 Actual and Predicted Temperature

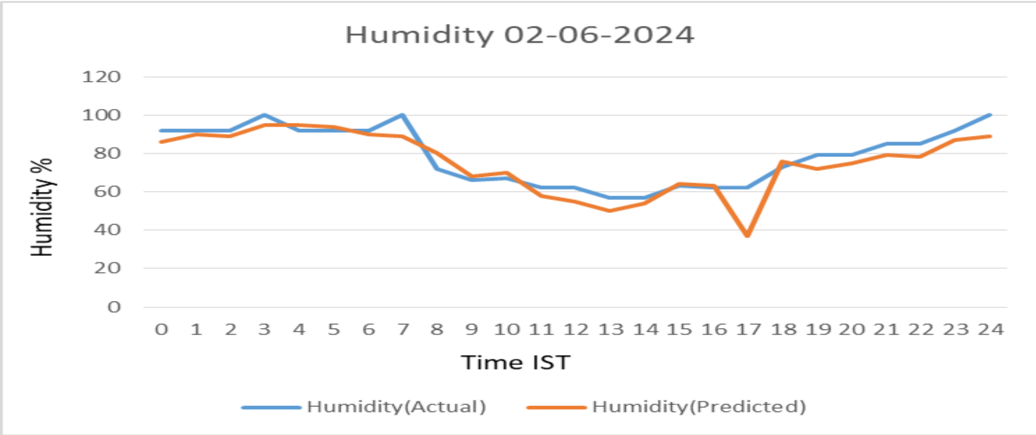


Fig. 4.98 Actual and Predicted Humidity

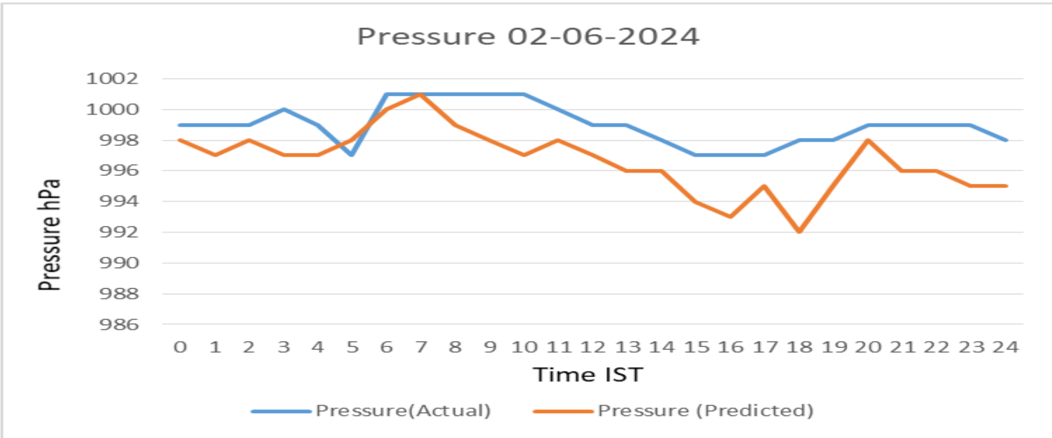


Fig. 4.99 Actual and Predicted Pressure

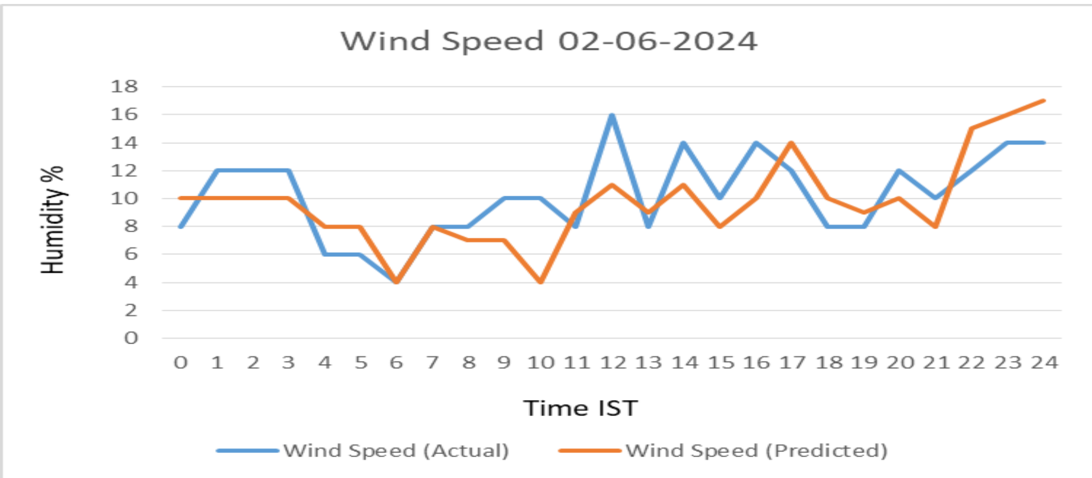


Fig. 4.100 Actual and Predicted Wind Speed

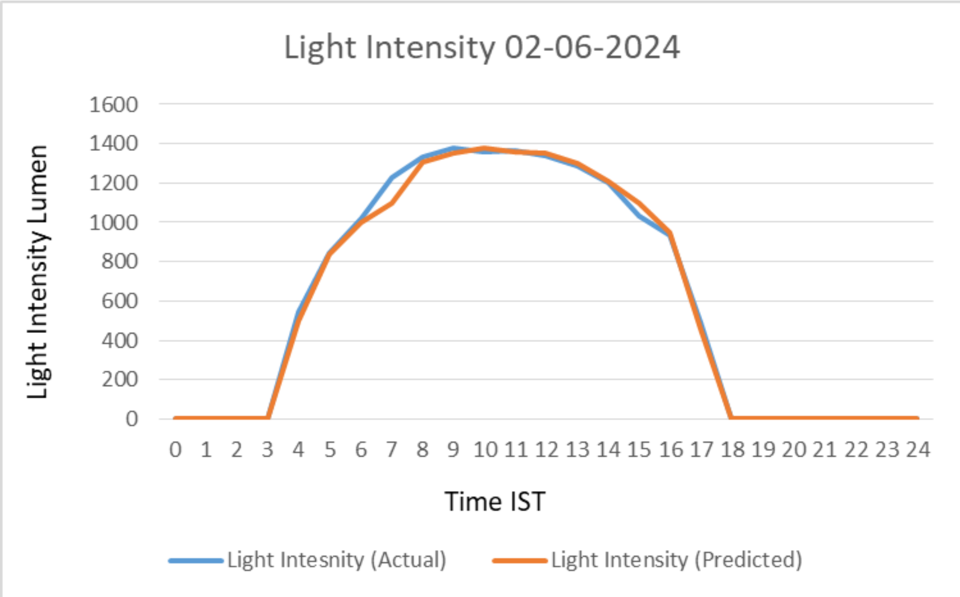


Fig. 4.101 Actual and Predicted Light Intensity

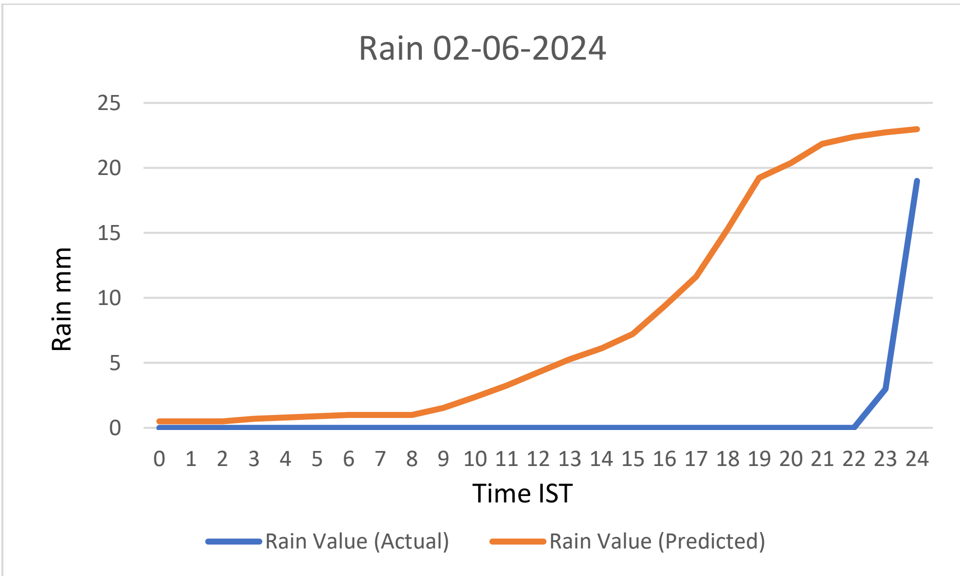


Fig. 4.102 Actual and Predicted Rain

Table 18: Predicted and actual data (03-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	03-06-24	00:00:00	28	24	100	95	0	0	0	0.5	14	10	998	1000
2	03-06-24	01:00:00	27	25	100	90	0	0	0	2.6	6	8	997	993
3	03-06-24	02:00:00	27	26	92	89	0	0	0	5.8	12	7	997	993
4	03-06-24	03:00:00	27	26	92	88	0	0	0	7.3	16	10	998	995
5	03-06-24	04:00:00	27	25	92	95	0	2	0	7.8	16	14	998	995
6	03-06-24	05:00:00	27	25	92	84	148	150	8	11.2	20	17	999	995
7	03-06-24	06:00:00	26	25	100	94	693	700	18.5	15.6	6	8	1000	998
8	03-06-24	07:00:00	27	27	92	95	946	950	29.1	20.9	10	7	1000	996
9	03-06-24	08:00:00	26	30	100	94	952	954	37.5	31.8	6	10	1001	999
10	03-06-24	09:00:00	27	30	92	94	1051	1060	42.1	38.6	8	2	1001	996
11	03-06-24	10:00:00	27	33	92	95	1100	1199	43.6	40.2	6	10	1000	997
12	03-06-24	11:00:00	29	33	79	82	1159	1200	0	41.6	4	7	999	998
13	03-06-24	12:00:00	30	33	72	76	1209	1234	0	42.8	0	5	999	994
14	03-06-24	13:00:00	31	33	67	72	890	900	0	36.8	8	9	998	997
15	03-06-24	14:00:00	31	34	73	71	807	806	0	30.5	8	10	997	993
16	03-06-24	15:00:00	31	34	73	71	397	400	0	28.3	14	10	990	993
17	03-06-24	16:00:00	31	37	73	76	350	360	0	27.8	12	14	996	992
18	03-06-24	17:00:00	31	35	79	80	235	260	0	10.6	14	15	996	993
19	03-06-24	18:00:00	30	33	85	83	0	0	0	12.1	14	17	996	994
20	03-06-24	19:00:00	29	31	85	84	0	0	0	18.3	10	16	996	995
21	03-06-24	20:00:00	30	30	92	86	0	0	0	18.4	8	9	997	995
22	03-06-24	21:00:00	28	29	92	89	0	0	0	19.6	12	18	998	996
23	03-06-24	22:00:00	28	32	92	90	0	0	0	20.3	12	16	998	997
24	03-06-24	23:00:00	27	26	92	93	0	0	0	25.9	18	19	999	998
25	03-06-24	24:00:00	28	25	100	95	0	0	46.8	34.6	10	15	999	999

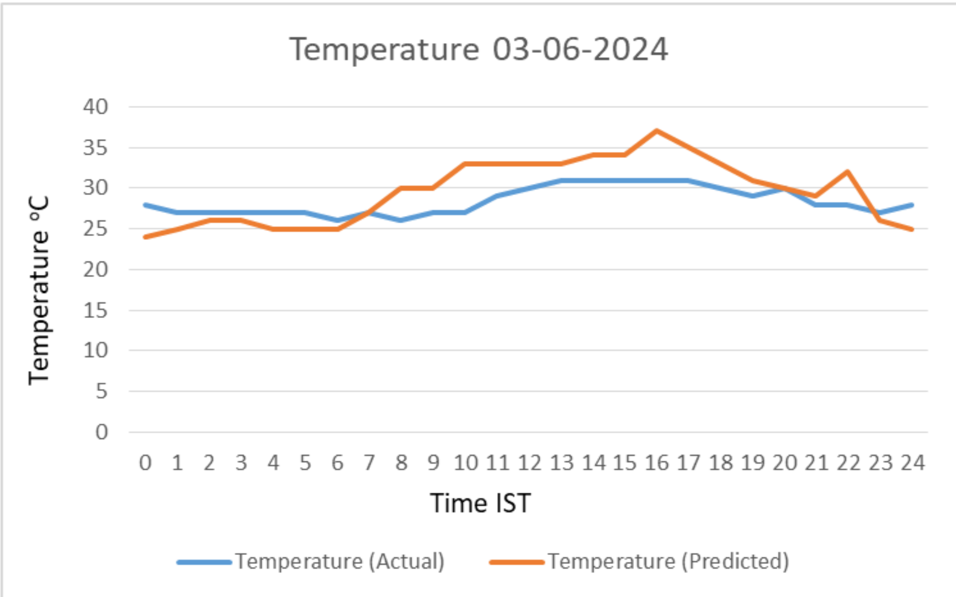


Fig. 4.103 Actual and Predicted Temperature

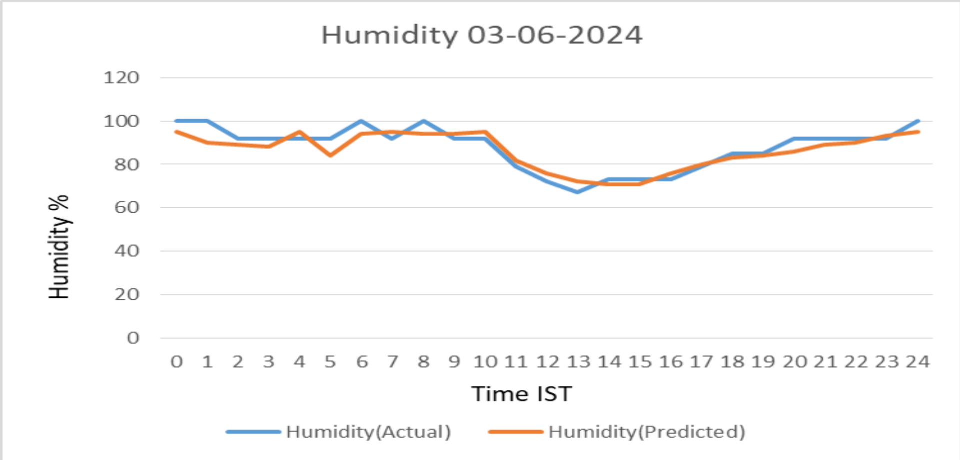


Fig. 4.104 Actual and Predicted Humidity

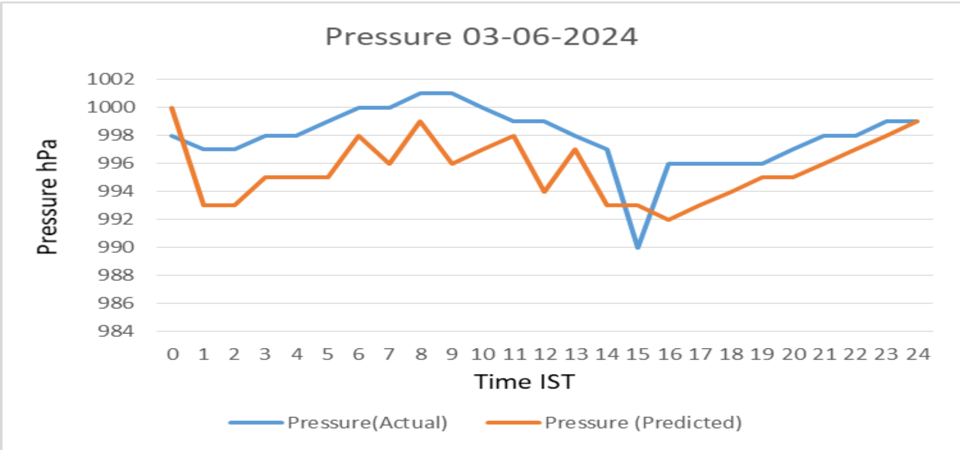


Fig. 4.105 Actual and Predicted Pressure

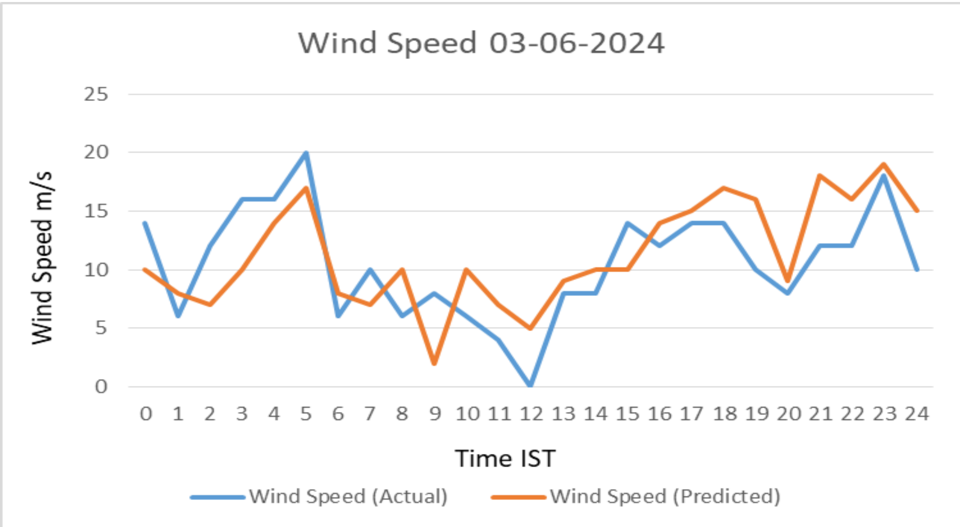


Fig. 4.106 Actual and Predicted Wind Speed

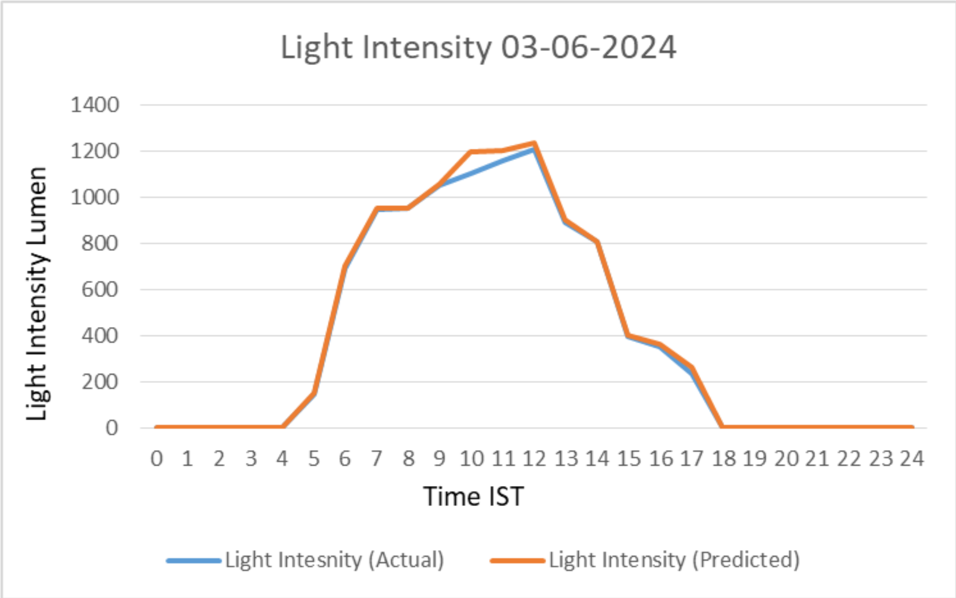


Fig. 4.107 Actual and Predicted Light Intensity

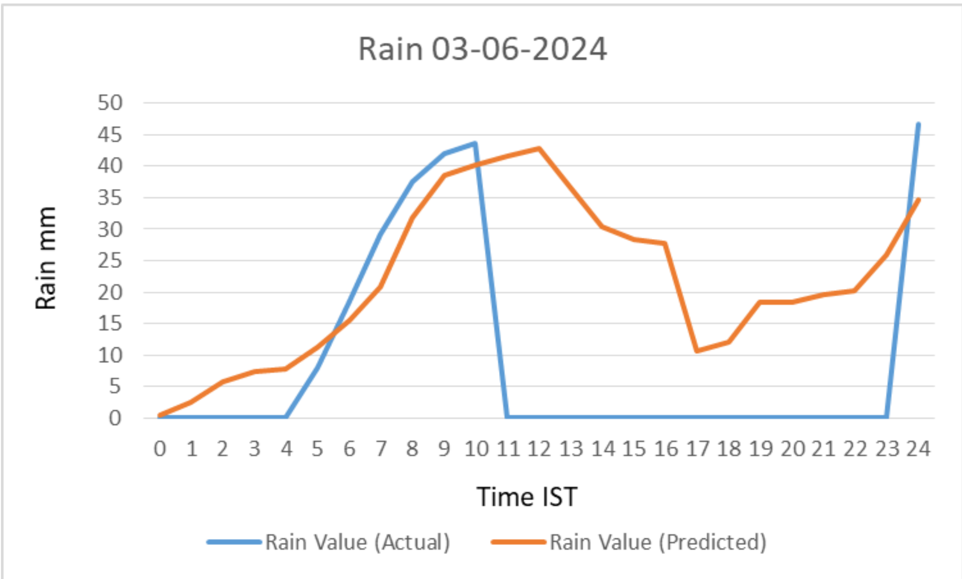


Fig. 4.108 Actual and Predicted Rain

Table 19: Predicted and actual data (04-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Value	Rain Value	Wind Spe	Wind Spe	Pressure(	Pressure (
1	04-06-24	00:00:00	27	24	100	85	0	0	3.6	0.5	18	17	999	998
2	04-06-24	01:00:00	28	25	92	90	0	0	9.8	2.3	10	14	999	999
3	04-06-24	02:00:00	27	26	92	86	0	0	14.6	8.9	6	8	998	999
4	04-06-24	03:00:00	26	26	100	97	464	400	22.3	15.3	6	9	999	1000
5	04-06-24	04:00:00	27	25	100	95	571	580	0	0.8	6	11	999	999
6	04-06-24	05:00:00	28	25	92	90	924	674	0	0.9	6	12	999	998
7	04-06-24	06:00:00	28	25	92	93	891	890	0	1	6	9	1000	1000
8	04-06-24	07:00:00	27	27	92	94	1292	1290	0	1	0	4	1001	1001
9	04-06-24	08:00:00	28	30	92	90	1301	1300	0	1	4	10	1002	1000
10	04-06-24	09:00:00	30	30	92	91	1308	1349	26.2	21.7	8	7	1002	1002
11	04-06-24	10:00:00	39	33	92	96	1167	1245	0	2.36	8	9	1001	999
12	04-06-24	11:00:00	30	33	85	84	1328	1299	0	3.25	8	10	1001	999
13	04-06-24	12:00:00	32	33	79	81	1320	1300	0	4.28	12	15	1000	998
14	04-06-24	13:00:00	31	33	73	75	1295	1296	0	5.28	12	15	999	997
15	04-06-24	14:00:00	33	34	79	80	1064	1023	0	6.12	10	15	998	996
16	04-06-24	15:00:00	31	34	74	74	825	785	0	7.22	16	10	998	994
17	04-06-24	16:00:00	31	34	73	73	741	730	0	9.36	14	16	997	996
18	04-06-24	17:00:00	31	32	79	81	610	600	0	8.3	10	10	997	995
19	04-06-24	18:00:00	31	29	86	89	0	0	0	6.2	12	8	997	997
20	04-06-24	19:00:00	30	27	86	84	0	0	0	5.3	8	8	998	998
21	04-06-24	20:00:00	30	28	85	88	0	0	0	4.3	8	4	999	998
22	04-06-24	21:00:00	29	26	85	86	0	0	0	5.3	10	5	1000	1000
23	04-06-24	22:00:00	28	25	92	93	0	0	0	2.6	4	7	1000	1001
24	04-06-24	23:00:00	28	26	100	96	0	0	0	1.2	6	10	1001	1000
25	04-06-24	24:00:00	29	25	100	98	0	0	0	0.6	6	10	1000	1000

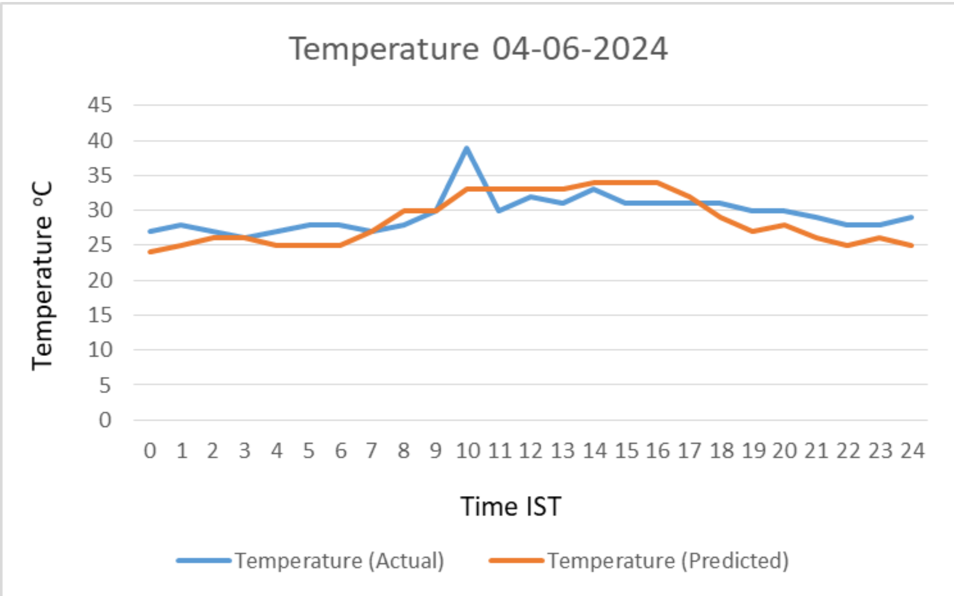


Fig. 4.109 Actual and Predicted Temperature

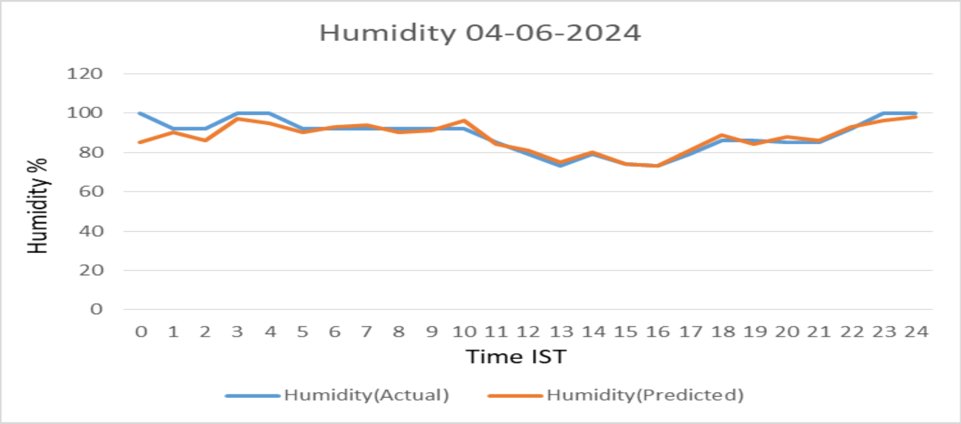


Fig. 4.110 Actual and Predicted Humidity

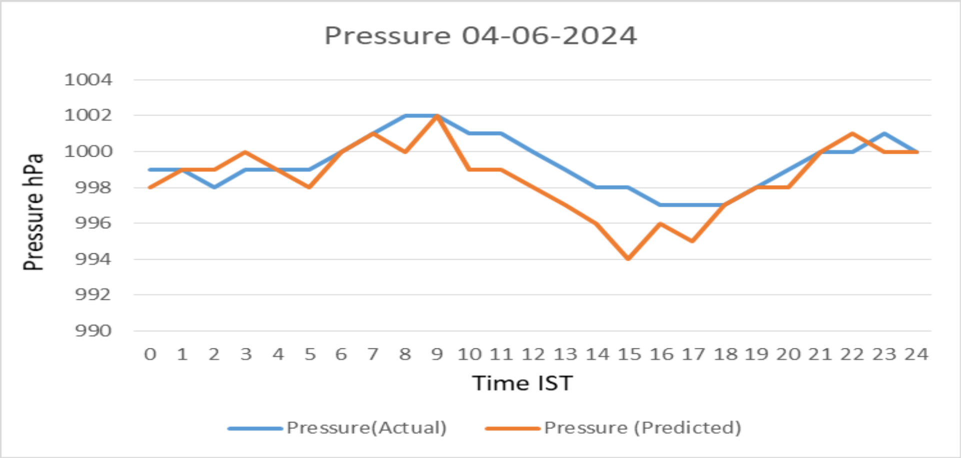


Fig. 4.111 Actual and Predicted Pressure

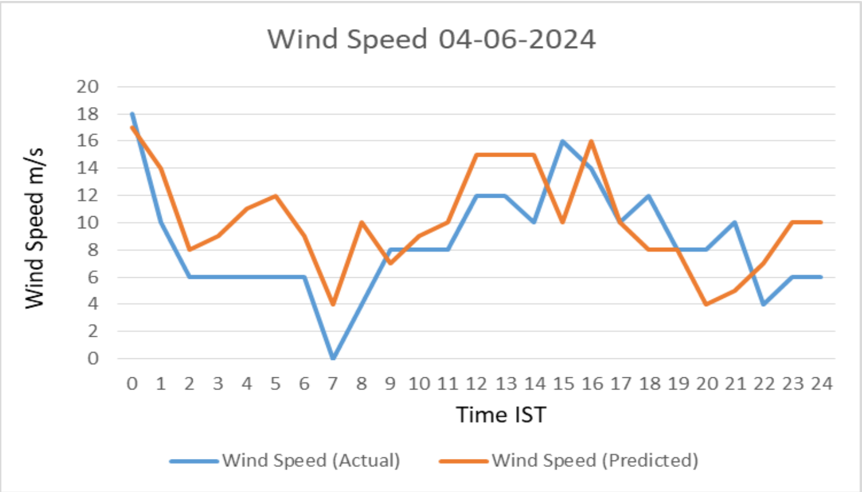


Fig. 4.112 Actual and Predicted Wind Speed

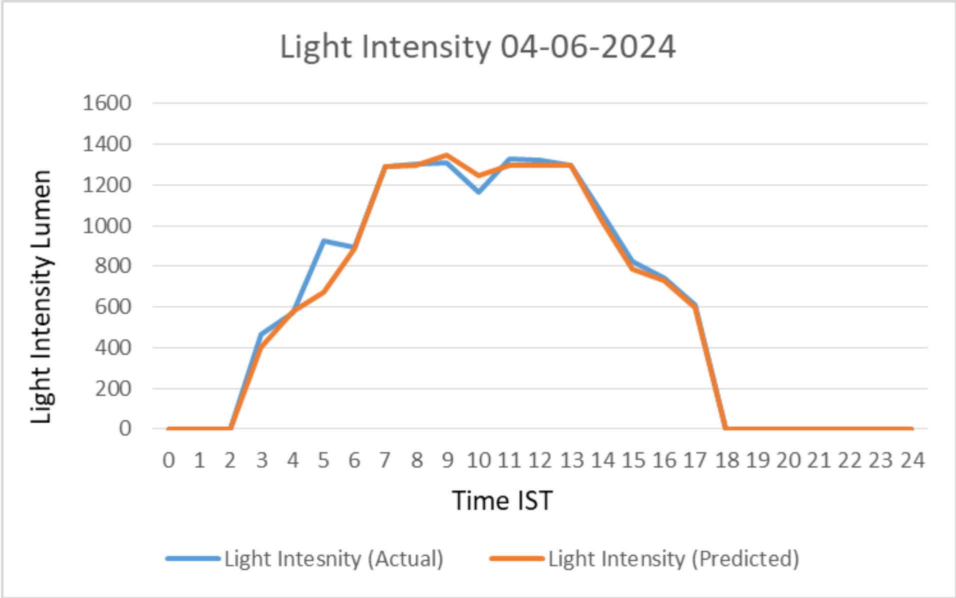


Fig. 4.113 Actual and Predicted Light Intensity

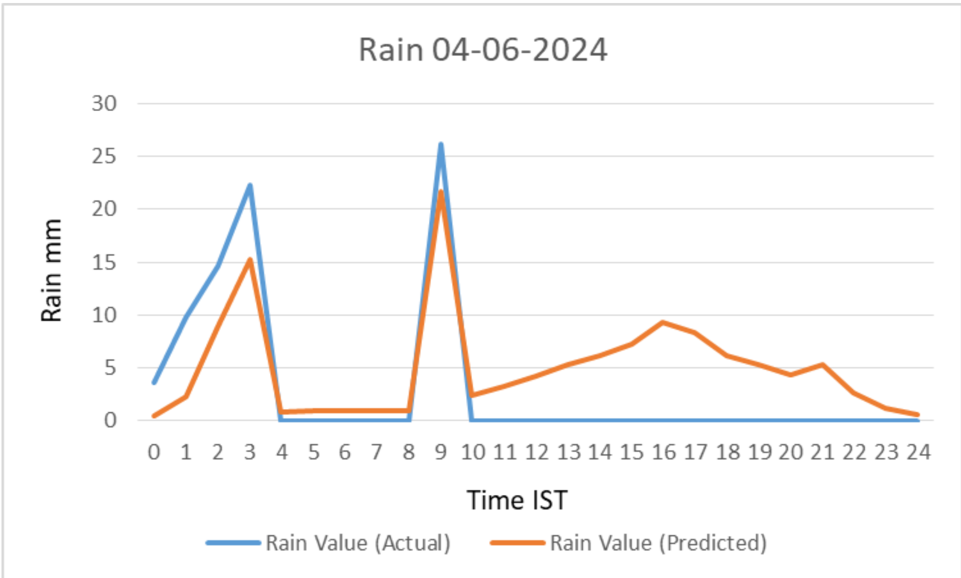


Fig. 4.114 Actual and Predicted Rain

Table 20: Predicted and actual data (05-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Valu	Rain Valu	Wind Spe	Wind Spe	Pressure(	Pressure (
1	05-06-24	00:00:00	29	24	92	85	0	0	0	0.6	6	8	1000	998
2	05-06-24	01:00:00	28	25	100	90	0	0	0	0.8	6	10	999	993
3	05-06-24	02:00:00	27	26	100	91	0	0	0	1.2	8	12	999	998
4	05-06-24	03:00:00	27	26	100	93	0	0	0	1.5	6	8	999	995
5	05-06-24	04:00:00	29	25	92	95	28	30	0	1.8	4	9	999	999
6	05-06-24	05:00:00	27	25	92	90	58	60	0	2.3	6	5	999	998
7	05-06-24	06:00:00	30	25	92	90	223	225	0	1.3	6	9	1000	995
8	05-06-24	07:00:00	26	27	92	91	452	460	0.5	0.9	4	8	1002	998
9	05-06-24	08:00:00	27	30	92	93	682	689	1.2	1.6	4	10	1001	999
10	05-06-24	09:00:00	27	30	100	94	797	801	2.6	2.3	4	14	1002	1000
11	05-06-24	10:00:00	28	33	100	96	964	987	3.4	4.3	10	18	1001	999
12	05-06-24	11:00:00	29	33	92	90	1020	1100	5.2	6.3	8	9	1001	999
13	05-06-24	12:00:00	31	33	67	70	1002	1001	0	0.6	4	6	1000	998
14	05-06-24	13:00:00	32	33	62	64	835	832	0	0.8	6	9	999	995
15	05-06-24	14:00:00	32	34	62	67	706	701	0	0.9	8	11	999	993
16	05-06-24	15:00:00	33	34	42	40	555	556	0	0.3	4	8	998	993
17	05-06-24	16:00:00	33	34	47	43	264	235	0	1.5	6	8	997	998
18	05-06-24	17:00:00	33	32	47	47	150	145	0	2.9	0	3	997	998
19	05-06-24	18:00:00	33	29	52	55	0	0	0	1.3	6	5	997	997
20	05-06-24	19:00:00	30	27	79	80	0	0	0	0.9	8	9	998	998
21	05-06-24	20:00:00	30	28	85	86	0	0	0	0.3	4	9	999	998
22	05-06-24	21:00:00	31	26	92	88	0	0	0	0.8	4	12	1000	1000
23	05-06-24	22:00:00	29	25	92	89	0	0	0	1.3	0	4	1000	1001
24	05-06-24	23:00:00	30	26	92	89	0	0	0	2.6	4	8	1000	1000
25	05-06-24	24:00:00	30	25	92	95	0	0	0	0.3	4	6	1000	1000

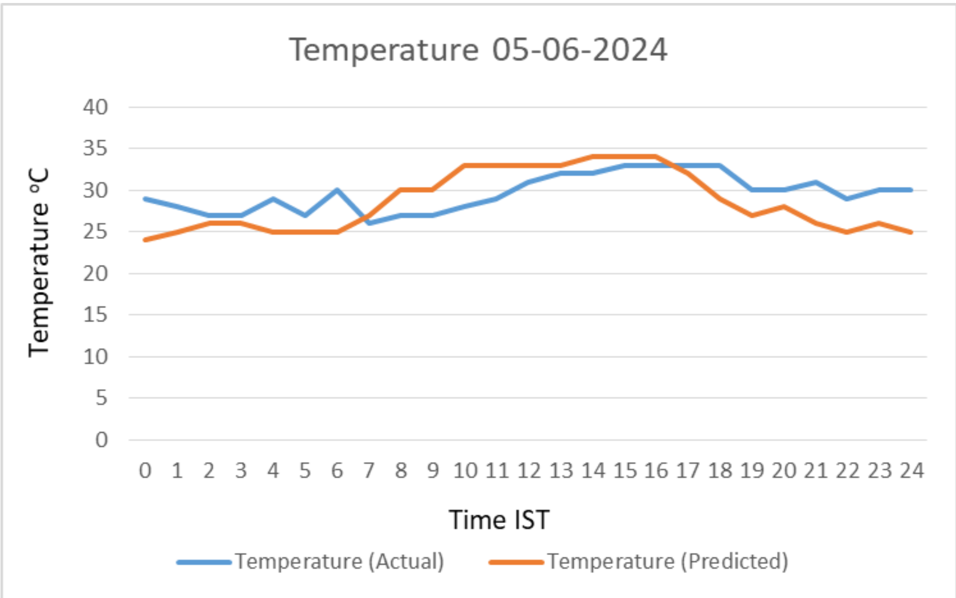


Fig. 4.115 Actual and Predicted Temperature

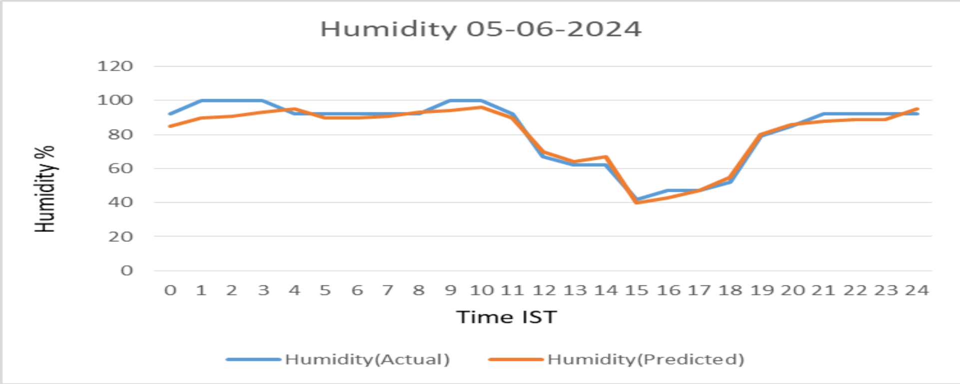


Fig. 4.116 Actual and Predicted Humidity

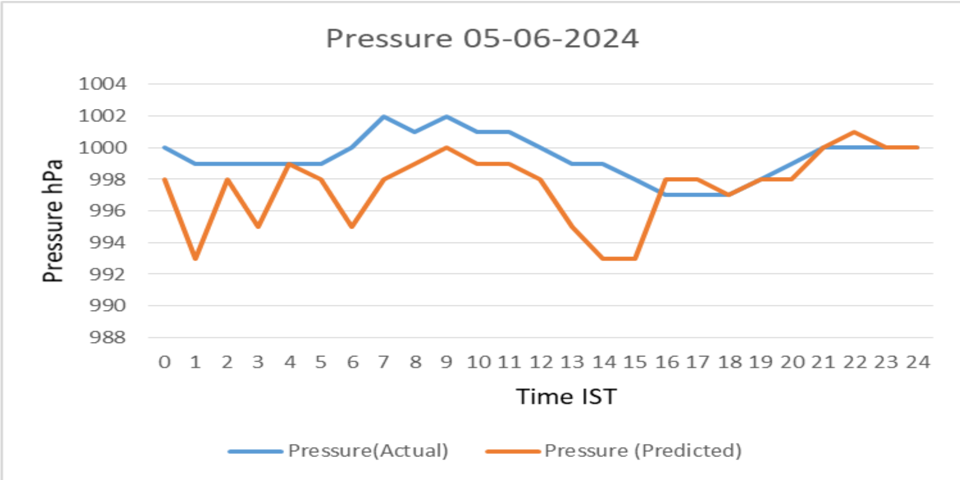


Fig. 4.117 Actual and Predicted Pressure

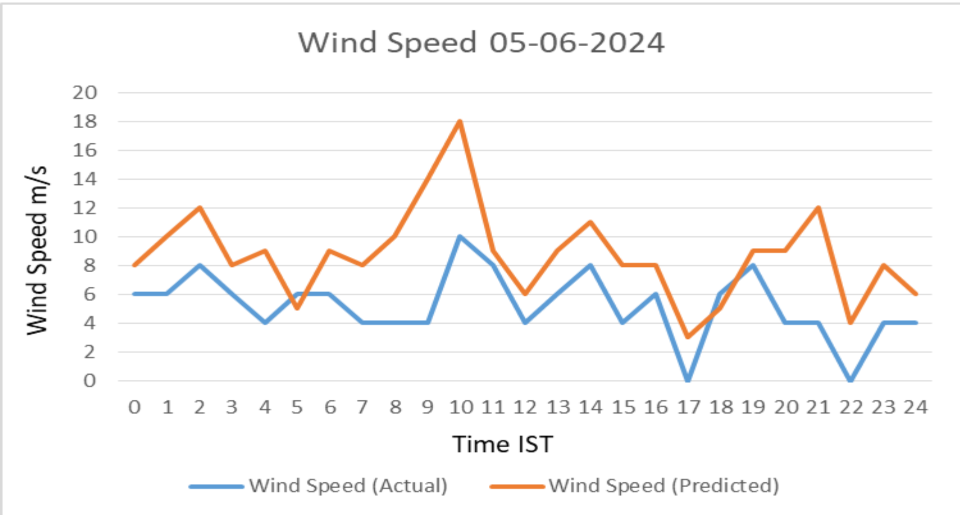


Fig. 4.118 Actual and Predicted Wind Speed

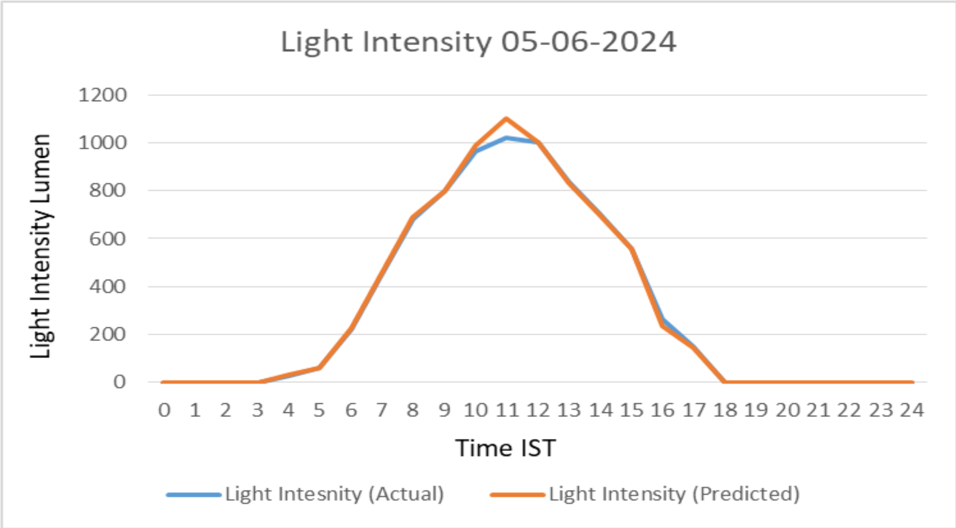


Fig. 4.119 Actual and Predicted Light Intensity

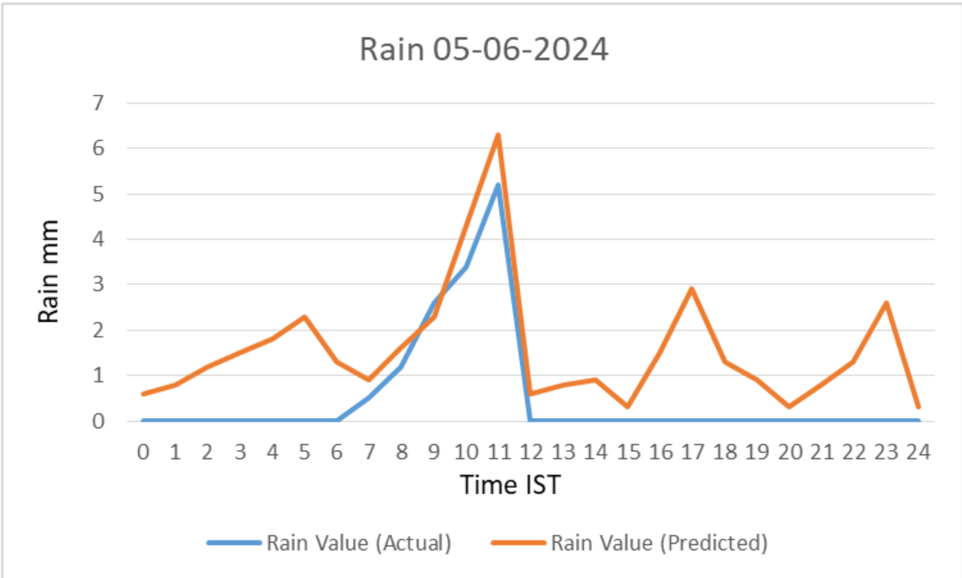


Fig. 4.120 Actual and Predicted Rain

Table 21: Predicted and actual data (06-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Valu	Rain Valu	Wind Spe	Wind Spe	Pressure(	Pressure (
1	06-06-24	00:00:00	30	24	92	85	0	0	0	0	4	9	1000	998
2	06-06-24	01:00:00	29	25	92	90	0	0	0	0	4	10	999	999
3	06-06-24	02:00:00	29	26	92	86	0	0	0	0	4	8	999	999
4	06-06-24	03:00:00	29	26	100	90	464	400	0	0.2	6	7	999	1000
5	06-06-24	04:00:00	29	25	100	95	571	580	0	0.1	6	8	999	999
6	06-06-24	05:00:00	29	25	92	91	924	674	0.5	0.3	6	4	999	998
7	06-06-24	06:00:00	30	25	85	80	891	890	1.2	0.5	64	27	1000	1000
8	06-06-24	07:00:00	30	27	85	88	1292	1290	0	0.7	8	12	1001	1001
9	06-06-24	08:00:00	30	30	79	71	1301	1300	0	0.8	6	10	1001	1000
10	06-06-24	09:00:00	31	30	68	53	1308	1349	0	0.6	8	9	1000	1002
11	06-06-24	10:00:00	33	33	68	70	1167	1245	0	0.5	4	6	1000	999
12	06-06-24	11:00:00	33	33	58	50	1328	1299	0	0.4	10	12	1000	999
13	06-06-24	12:00:00	34	33	58	50	1320	1300	0	0.2	6	8	999	998
14	06-06-24	13:00:00	34	33	63	60	1295	1296	0	0.2	8	9	998	997
15	06-06-24	14:00:00	34	34	53	54	1064	1023	0	0.1	14	15	997	996
16	06-06-24	15:00:00	35	34	58	60	825	785	0	0.1	6	10	997	994
17	06-06-24	16:00:00	34	34	68	70	741	730	0	0.2	8	11	996	996
18	06-06-24	17:00:00	35	32	80	83	610	600	0	0.1	10	10	996	995
19	06-06-24	18:00:00	34	35	79	84	0	0	0	0.3	8	8	996	997
20	06-06-24	19:00:00	33	32	92	93	0	0	0	0.2	0	4	996	998
21	06-06-24	20:00:00	33	28	92	95	0	0	0	0.1	4	4	997	998
22	06-06-24	21:00:00	32	26	100	99	0	0	0	0.2	4	5	998	1000
23	06-06-24	22:00:00	32	25	92	95	0	0	0	0	0	5	999	1001
24	06-06-24	23:00:00	31	30	92	94	0	0	0	0	4	10	998	1000
25	06-06-24	24:00:00	31	32	100	98	0	0	0	0	0	10	998	1000

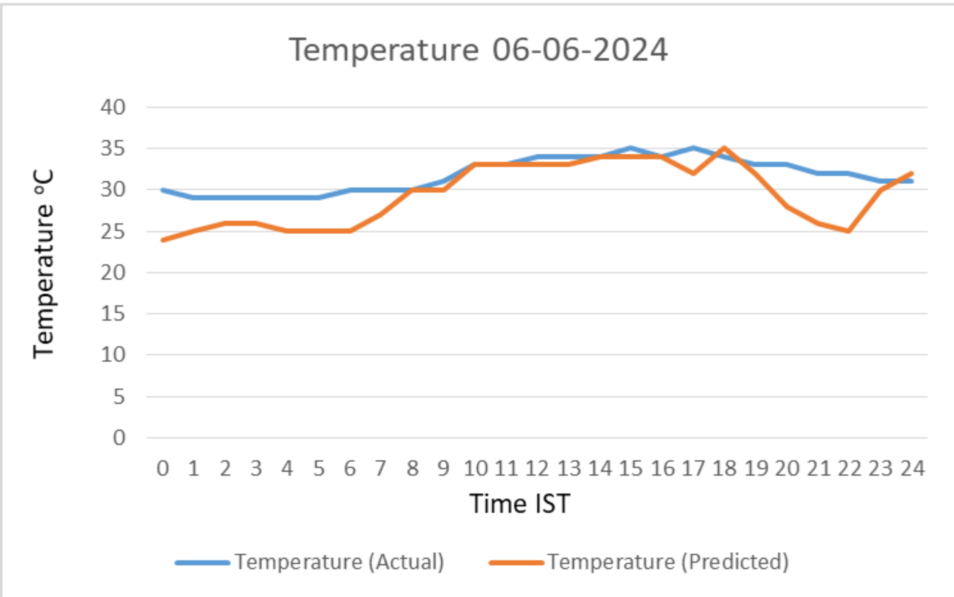


Fig. 4.121 Actual and Predicted Temperature

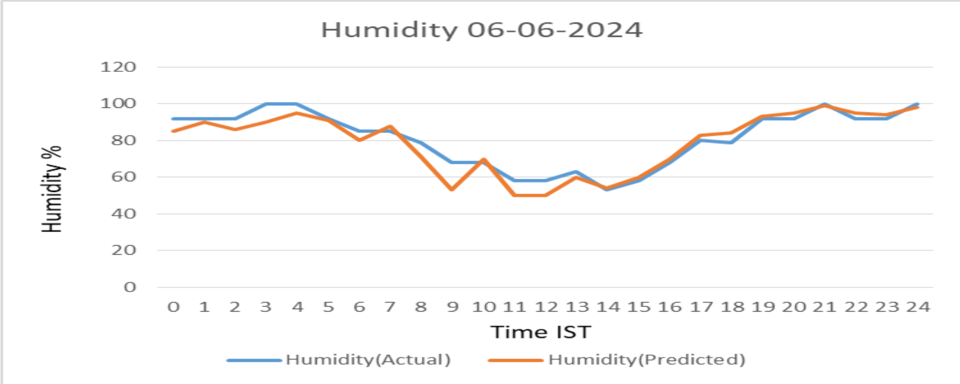


Fig. 4.122 Actual and Predicted Humidity

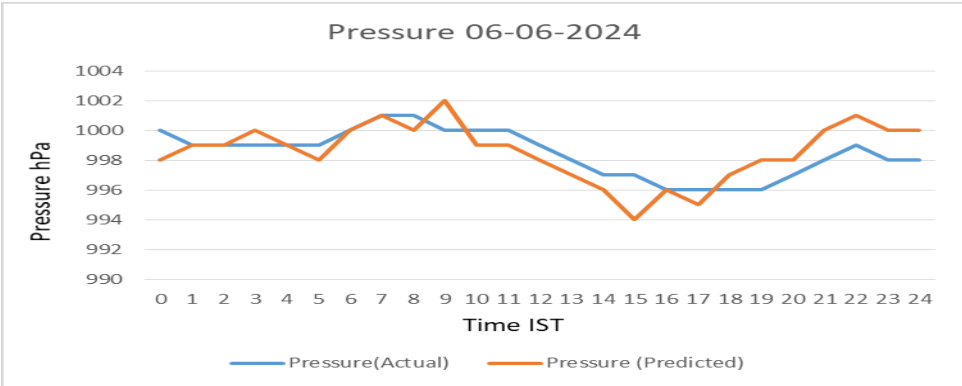


Fig. 4.123 Actual and Predicted Pressure

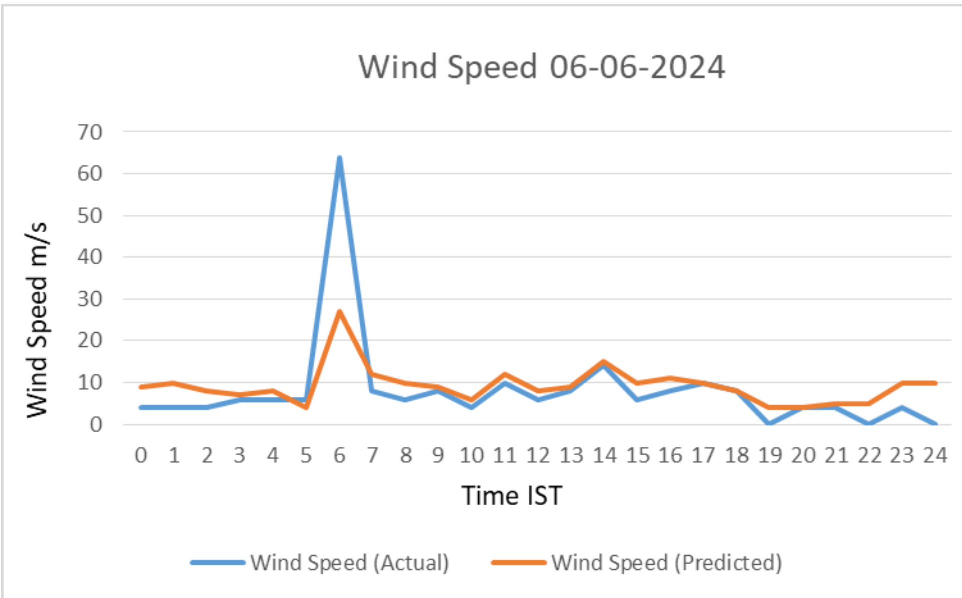


Fig. 4.124 Actual and Predicted Wind Speed

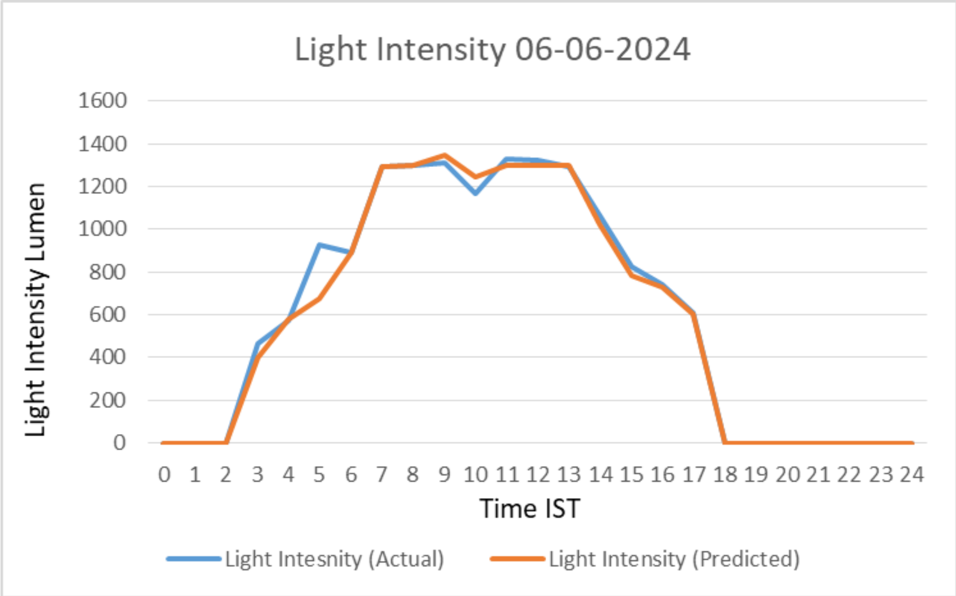


Fig. 4.125 Actual and Predicted Light Intensity

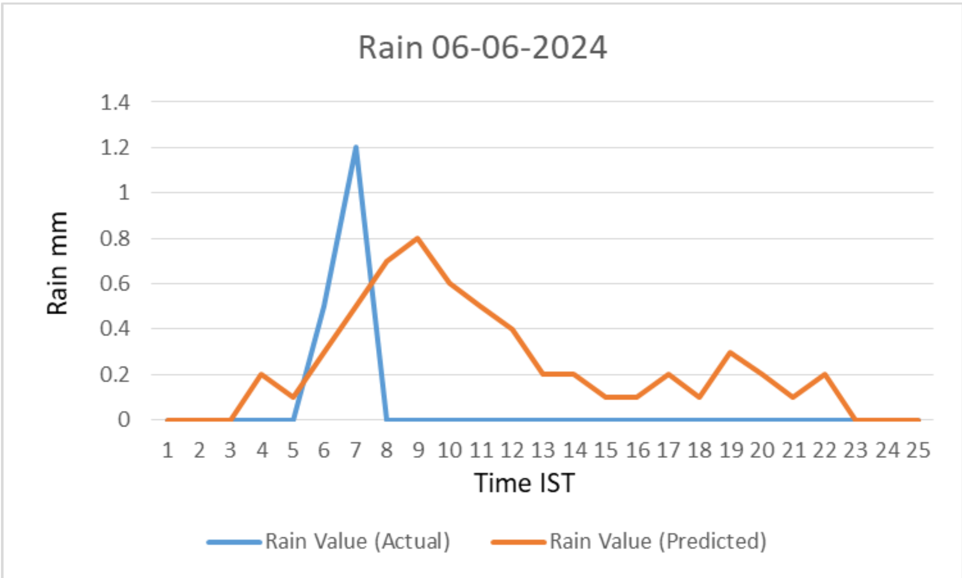


Fig. 4.126 Actual and Predicted Rain

Table 22: Predicted and actual data (07-06-2024)

Sl No.	Date	Time	Temperat	Temperat	Humidity(	Humidity(	Light Intes	Light Inter	Rain Valu	Rain Valu	Wind Spe	Wind Spe	Pressure(	Pressure (
1	07-06-24	00:00:00	31	30	92	90	0	0	0	0	0	4	998	999
2	07-06-24	01:00:00	31	25	92	91	0	0	0	0	6	6	997	999
3	07-06-24	02:00:00	29	26	100	95	0	0	0	0	6	8	997	999
4	07-06-24	03:00:00	29	26	92	96	0	0	0	0.2	0	5	997	1000
5	07-06-24	04:00:00	29	25	92	93	0	0	0	0.1	4	8	997	999
6	07-06-24	05:00:00	29	25	92	94	554	600	0	0.3	0	3	997	998
7	07-06-24	06:00:00	30	26	100	99	678	628	0	0.5	6	7	998	1000
8	07-06-24	07:00:00	30	27	85	86	683	701	0	0.7	4	6	998	1001
9	07-06-24	08:00:00	31	28	79	80	789	824	0	0.8	0	4	998	1000
10	07-06-24	09:00:00	32	27	67	70	941	983	0	0.6	6	8	998	1002
11	07-06-24	10:00:00	33	27	68	71	976	985	0	0.5	6	7	998	999
12	07-06-24	11:00:00	34	33	58	60	947	954	0	0.4	12	10	997	997
13	07-06-24	12:00:00	35	29	53	55	920	904	0	0.2	12	10	996	995
14	07-06-24	13:00:00	36	35	62	60	635	623	0	0.2	12	9	995	997
15	07-06-24	14:00:00	36	29	40	45	555	532	0	0.1	10	11	994	996
16	07-06-24	15:00:00	33	28	49	50	336	376	0	0.1	12	10	993	995
17	07-06-24	16:00:00	31	27	58	60	121	150	0	0.2	10	7	993	996
18	07-06-24	17:00:00	30	32	85	84	54	80	0	0.1	16	10	995	997
19	07-06-24	18:00:00	30	29	79	74	0	0	0	0.3	10	8	995	997
20	07-06-24	19:00:00	30	27	92	83	0	0	0	0.2	8	7	996	998
21	07-06-24	20:00:00	30	28	92	94	0	0	0	0.1	6	9	996	998
22	07-06-24	21:00:00	31	26	92	95	0	0	0	0.2	4	7	996	1000
23	07-06-24	22:00:00	29	25	85	93	0	0	0	0	0	4	995	999
24	07-06-24	23:00:00	30	27	92	94	0	0	0	0	0	4	995	998
25	07-06-24	24:00:00	29	25	92	98	0	0	0	0	4	2	996	999

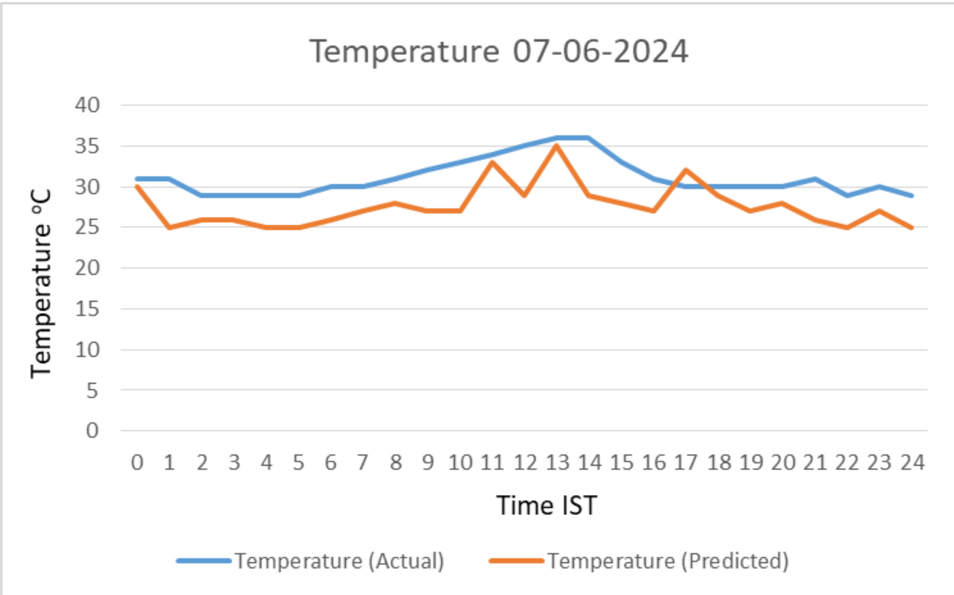


Fig. 4.127 Actual and Predicted Temperature

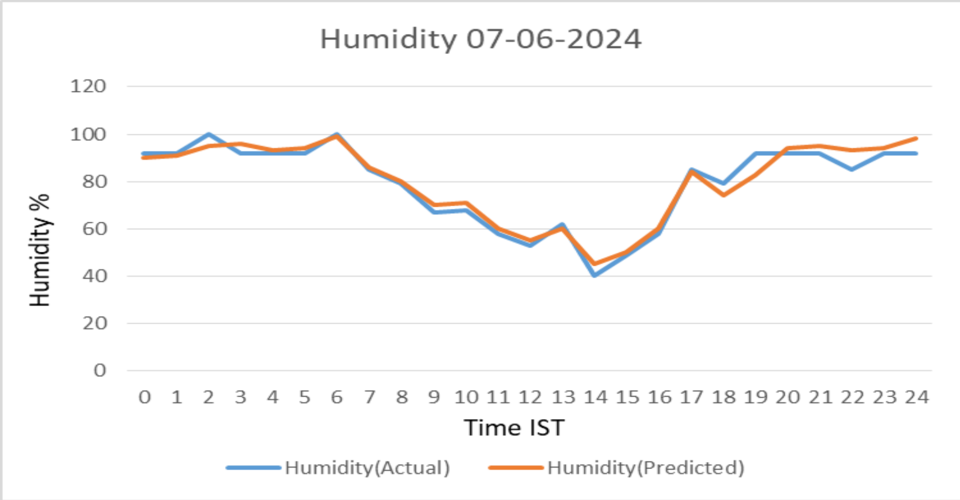


Fig. 4.128 Actual and Predicted Humidity

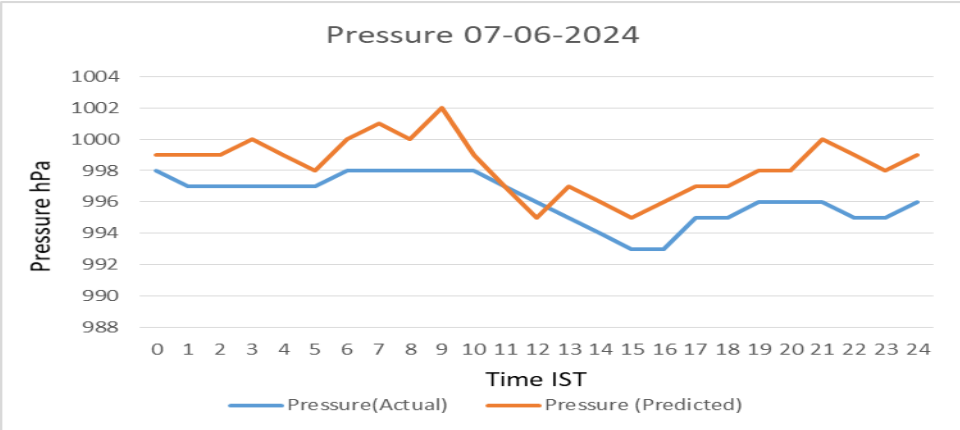


Fig. 4.129 Actual and Predicted Pressure

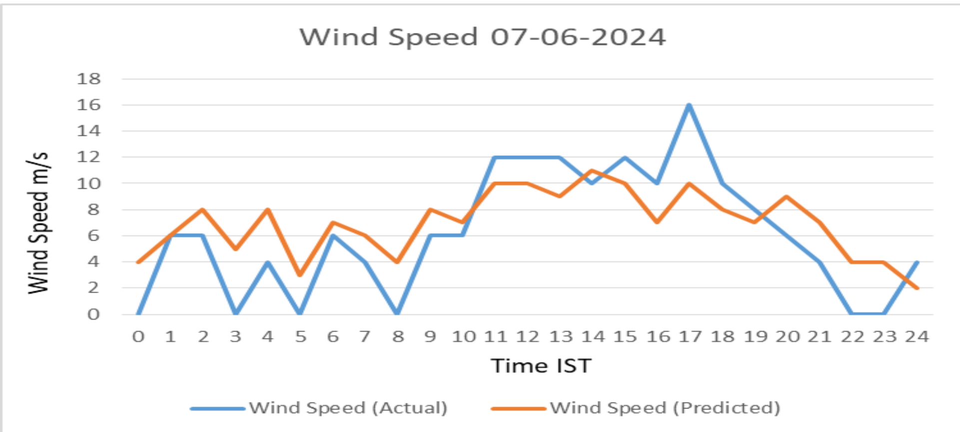


Fig. 4.130 Actual and Predicted Wind Speed

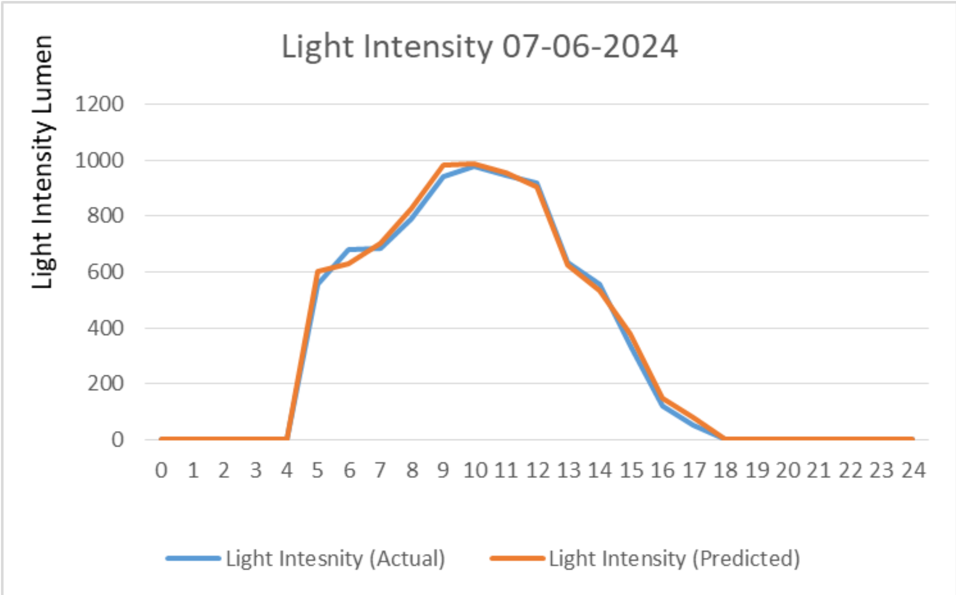


Fig. 4.131 Actual and Predicted Light Intensity

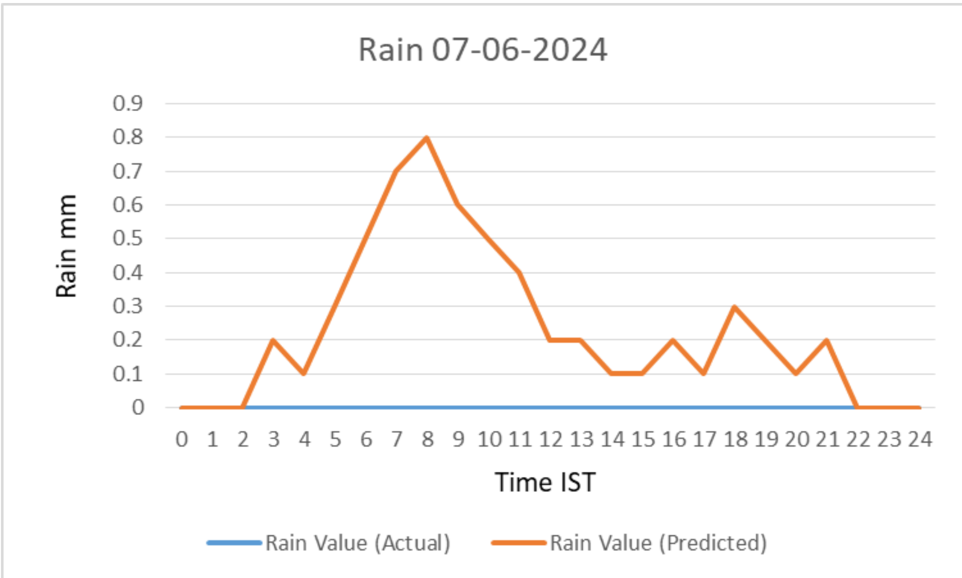


Fig. 4.132 Actual and Predicted Rain

4.2 Data Monitoring and Prediction

After switching ON the device, Wi-Fi hotspot is connected with raspberry pi and laptop. From Real VNC Viewer in which raspberry pi OS can be seen. After running of program an IP address is generated. This IP address can be opened via any browser in which the webpage can be displayed. In the webpage all the real time data with graph can be seen and recorded past data can be downloaded from it in csv file for further analysis.

The machine learning code using python is written in thonny software, the weather prediction system is displayed on the webpage, here data is given as input whose prediction needs to be seen. It will display minimum and maximum of the parameters along with Mean Square Error (MSE).

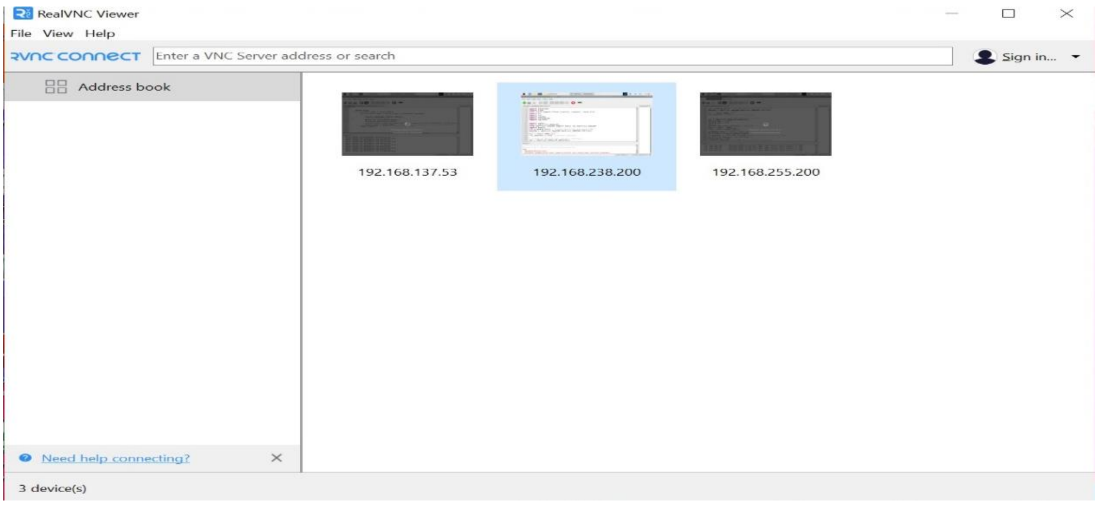


Figure 4.133 – Real VNC Viewer

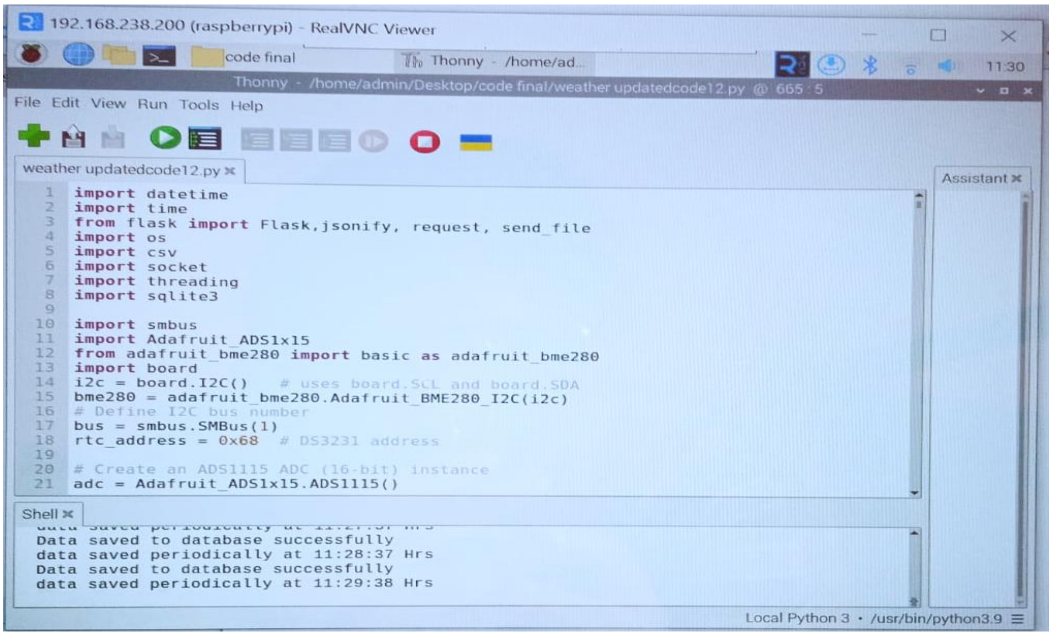


Figure 4.134 – Thonny IDE

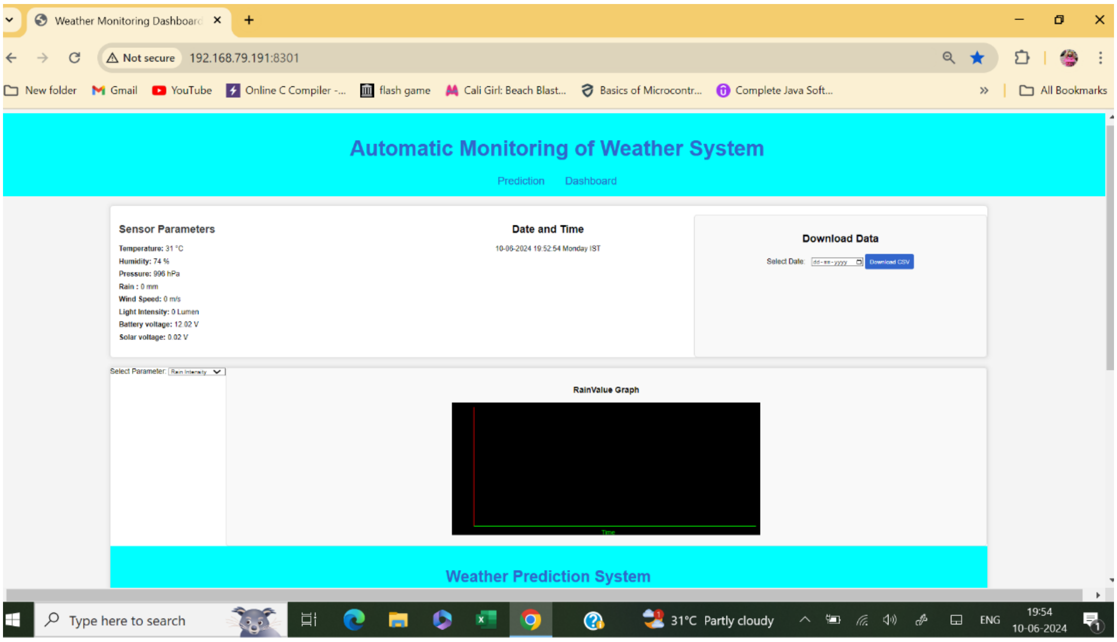
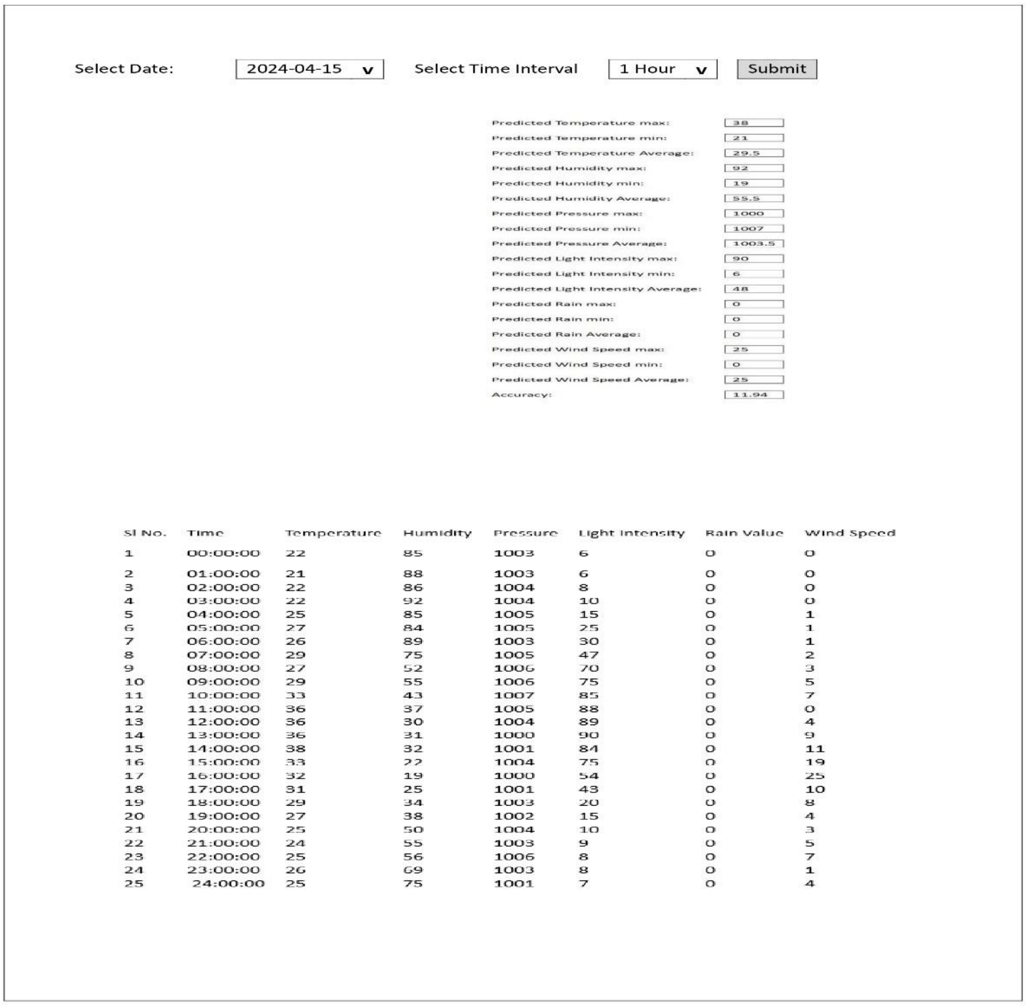


Fig 4.135 Weather monitoring webpage

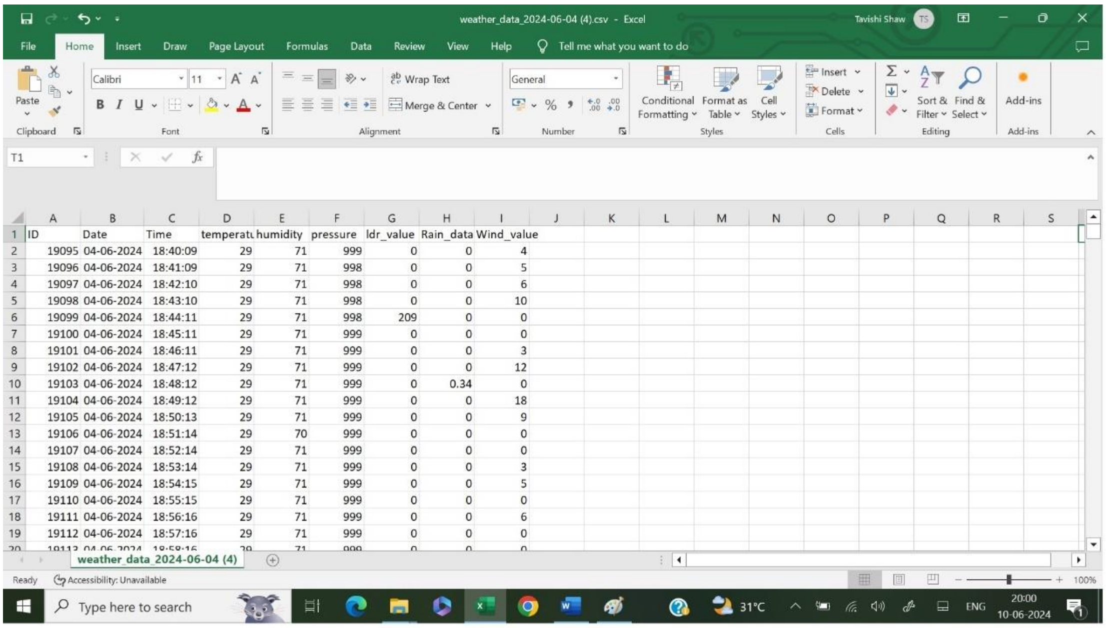


Select Date: 2024-04-15 v Select Time Interval 1 Hour v Submit

Predicted Temperature max:	38
Predicted Temperature min:	21
Predicted Temperature Average:	29.5
Predicted Humidity max:	92
Predicted Humidity min:	19
Predicted Humidity Average:	55.5
Predicted Pressure max:	1000
Predicted Pressure min:	1007
Predicted Pressure Average:	1003.5
Predicted Light Intensity max:	90
Predicted Light Intensity min:	6
Predicted Light Intensity Average:	48
Predicted Rain max:	0
Predicted Rain min:	0
Predicted Rain Average:	0
Predicted Wind Speed max:	25
Predicted Wind Speed min:	0
Predicted Wind Speed Average:	25
Accuracy:	11.94

Sl No.	Time	Temperature	Humidity	Pressure	Light Intensity	Rain Value	Wind Speed
1	00:00:00	22	85	1003	6	0	0
2	01:00:00	21	88	1003	6	0	0
3	02:00:00	22	86	1004	8	0	0
4	03:00:00	22	92	1004	10	0	0
5	04:00:00	25	85	1005	15	0	1
6	05:00:00	27	84	1005	25	0	1
7	06:00:00	26	89	1003	30	0	1
8	07:00:00	29	75	1005	47	0	2
9	08:00:00	27	52	1006	70	0	3
10	09:00:00	29	55	1006	75	0	5
11	10:00:00	33	43	1007	85	0	7
12	11:00:00	36	37	1005	88	0	0
13	12:00:00	36	30	1004	89	0	4
14	13:00:00	36	31	1000	90	0	9
15	14:00:00	38	32	1001	84	0	11
16	15:00:00	33	22	1004	75	0	19
17	16:00:00	32	19	1000	54	0	25
18	17:00:00	31	25	1001	43	0	10
19	18:00:00	29	34	1003	20	0	8
20	19:00:00	27	38	1002	15	0	4
21	20:00:00	25	50	1004	10	0	3
22	21:00:00	24	55	1003	9	0	5
23	22:00:00	25	56	1006	8	0	7
24	23:00:00	26	69	1003	8	0	1
25	24:00:00	25	75	1001	7	0	4

Fig 4.136 Weather Prediction Webpage



ID	Date	Time	temperatu	humidity	pressure	ldr_value	Rain_data	Wind_value
19095	04-06-2024	18:40:09	29	71	999	0	0	4
19096	04-06-2024	18:41:09	29	71	998	0	0	5
19097	04-06-2024	18:42:10	29	71	998	0	0	6
19098	04-06-2024	18:43:10	29	71	998	0	0	10
19099	04-06-2024	18:44:11	29	71	998	209	0	0
19100	04-06-2024	18:45:11	29	71	999	0	0	0
19101	04-06-2024	18:46:11	29	71	999	0	0	3
19102	04-06-2024	18:47:12	29	71	999	0	0	12
19103	04-06-2024	18:48:12	29	71	999	0	0.34	0
19104	04-06-2024	18:49:12	29	71	999	0	0	18
19105	04-06-2024	18:50:13	29	71	999	0	0	9
19106	04-06-2024	18:51:14	29	70	999	0	0	0
19107	04-06-2024	18:52:14	29	71	999	0	0	0
19108	04-06-2024	18:53:14	29	71	999	0	0	3
19109	04-06-2024	18:54:15	29	71	999	0	0	5
19110	04-06-2024	18:55:15	29	71	999	0	0	0
19111	04-06-2024	18:56:16	29	71	999	0	0	6
19112	04-06-2024	18:57:16	29	71	999	0	0	0

Figure 4.137 – Example of csv file

Figure 4.138 - Project Sensors Kept In IMD Guwahati Observatory

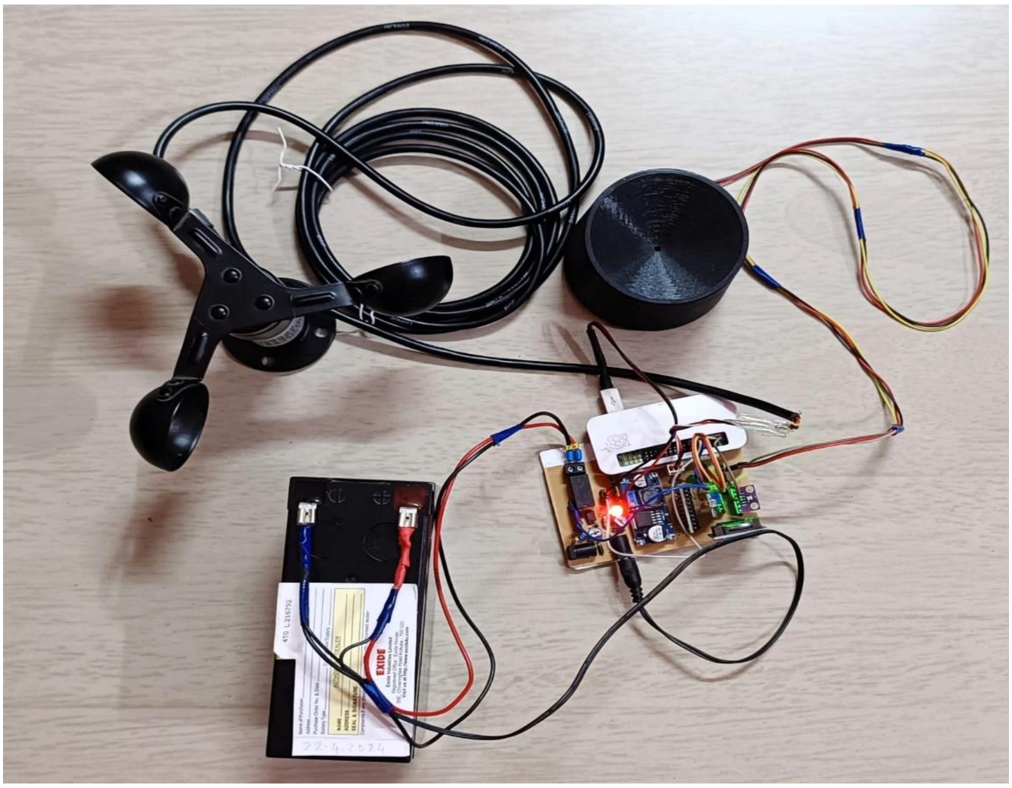


Figure 4.139 - Project Circuit

4.3 APPLICATIONS, ADVANTAGES AND LIMITATIONS

4.3.1 Applications

- Agriculture: Automatic weather monitoring systems help farmers make informed decisions regarding crop irrigation, fertilization, and pest control by providing real-time weather data. This enables them to optimize crop yields and conserve resources.
- Disaster Management: During natural disasters like hurricanes, floods, or wildfires, Automatic weather monitoring systems can provide crucial data for early warning systems. This helps in evacuating people, organizing relief efforts, and minimizing the impact of the disaster.
- Transportation and Logistics: Weather conditions significantly impact transportation and logistics. Automatic weather monitoring systems can provide real-time weather updates to optimize routes, improve safety, and reduce delays for various modes of transport, such as shipping, aviation, and road transportation.
- Smart Cities: In urban areas, Automatic weather monitoring systems can contribute to smart city initiatives by providing data for city planning, traffic management, energy consumption optimization, and infrastructure resilience against extreme weather events.
- Energy Management: Renewable energy sources like solar and wind power generation heavily depend on weather conditions. Automatic weather monitoring systems can optimize energy production by predicting weather patterns and adjusting energy generation accordingly.
- Outdoor Events and Recreation: Event organizers, sports venues, and recreational facilities can utilize Automatic weather monitoring to plan and manage outdoor activities. This helps in ensuring safety and providing a better experience for attendees or participants.
- Environmental Monitoring: Monitoring weather conditions is vital for understanding climate change and its impact on the environment. Automatic systems contribute valuable data for environmental research and conservation efforts.

- Home Automation: Automatic weather sensors integrated into smart home systems can automate functions like adjusting thermostats, controlling window shutters, or activating irrigation systems based on real-time weather conditions.

4.3.2 Advantages

- Real-time data collection: These devices and sensor, businesses get weather updates from all sorts of required locations when they need them.

- Wider coverage: Traditional weather monitoring systems usually check conditions at just a few weather stations, leaving out other areas. When IoT technology steps in, businesses can cover more places, even the most distant ones.

- Predictive analytics: IoT-powered weather reporting systems use historical data and current trends to tell businesses what's coming. That's how companies can adjust their operations before any weather-related challenges appear.

- Reduced response time: Every second counts when the industry is about making fast decisions aerospace or emergency services. That's where IoT weather monitoring comes in as a solution, offering real-time insights for rapid response times.

- Cost-effectiveness: A weather reporting system using IoT allows companies to optimize resource usage and reduce waste. For example, agriculture businesses can leverage weather forecasts to adjust their irrigation and crop protection measures.

- Increased safety: Industries prone to weather-related risks, like construction or transportation, enjoy the advantages of IoT-based automatic weather stations. These businesses can plan their activities more safely with a minimum of accidents and disruptions.

4.3.3 Limitations

- Technical complexity: Automatic weather monitoring system require the use of a large number of sensors and communication technologies, which are technically complex.
- Difficulty of data processing: There are large amount of data collected by the device, due to which the difficulty of data processing increases accordingly. For a large number of data collection and processing, high end hardware and software are needed.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

This project is a smart way to forecast weather parameters. The Weather Forecasting project embodies our dedication to creating solutions that bridge theory and application. Through the integration of sensors, data processing, machine learning, and our hardware competence, the aim is to contribute to accurate and accessible weather forecasting. It is efficient, reliable and low-cost system. The archived data will be helpful for future analysis and it can be easily shared to other users. It is highly useful for various sectors like aviation, agriculture, disaster management etc.

The future of weather applications is promising, with the increasing demand for real-time and accurate weather information. One potential development is the improvement in accuracy through the use of advanced data collection and analysis techniques, as well as sophisticated algorithms.

This project has demonstrated the successful implementation of an Environmental Monitoring System using the Raspberry Pi Zero W. It offers practical applications in home automation, weather monitoring, and more. Challenges were overcome, and the system proved to be accurate and reliable.

5.2 Future Works

Renewable energy is a present demand due to increasing concerns about climate change and environmental sustainability. Using solar panel will reduce the running cost of the device.

There is a great demand of weather monitoring and prediction system in various fields. This low cost automatic monitoring and forecast of weather system will definitely help in increasing the weather monitoring density as well as location specific weather forecast.

There is a growing trend towards integrating weather sensors into future smartphones and smartwatches. Some smartphones already come equipped with basic weather sensors like barometers for measuring atmospheric pressure. With advancements in sensor technology and consumer demand for more personalized and real-time weather information, it is likely that future smartphones and smartwatches will incorporate more advanced weather sensors such as temperature sensors, humidity sensors, UV sensors, and even air quality sensors. These sensors can provide users with more accurate and localized weather data, enhancing their overall user experience.

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