

IoT-Driven Environmental Monitoring and Healthcare System: Shipbreaking Industry Perspective



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Declaration

I, Afsana Ahmed, declare that this project titled, IoT-Driven Environmental Monitoring and Healthcare System: Shipbreaking Industry Perspective and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a MSc degree at United International University.
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- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this project is entirely my own work.
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I do hereby declare that the research works embodied in this project entitled IoT-Driven Environmental Monitoring and Healthcare System: Shipbreaking Industry Perspective is the outcome of an original work carried out by Afsana Ahmed under my supervision.

I further certify that the dissertation meets the requirements and the standard for the degree of MSc in Computer Science and Engineering.

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Abstract

The coastal region of Bangladesh has ecological importance with high biodiversity. Although Bangladesh is one of the world's top shipbreaking countries, business activities have seriously harmed the coastal ecosystem. The workers are subject to a hazardous environment that leaves them susceptible to a wide range of health disorders. The main goal of this study is to represent the situation of the shipbreaking industry regarding environmental pollution and realize the health condition of the workers. In this work, we have proposed an Internet of Things (IoT) based outdoor environment monitoring system where we have collected real-time data using 5 parameters like - temperature, humidity, dew point, surface pressure, and PM2.5 from Sitakunda Shipbreaking Industry. Cloud server have been used to upload and keep long-term storage of IoT data. We have also collected 2373 past data for the last 7 years (January 2016-June 2022) from NASA Power View, US Console Dhaka, and the Ministry of Environment Forests Bangladesh. We have made a health survey of different 6 hospitals in the Chittagong division for the health dataset, which is the unique and most challenging part of our work. From these past datasets and health surveys, we have analyzed the environmental pollution and also found in which season the risk factor of worker's health in the shipbreaking industry is "high", "medium" or "low". Then, we have built our model using various Machine Learning (ML) algorithms e.g., Decision Tree, Random Forest, KNN, Extra Tree Classifier, and Ensemble Method, and find better accuracy which is - 78.96%, 81.78%, 76.36%, 80.69%, and 80.04% respectively, where the Random Forest Classifier gives the best accuracy. Finally, based on our implementation a solution is identified to detect the affected rate of the environment and the healthy environment margin. This solution is mainly based on the Sitakunda area which will help to estimate and send the threats about shipbreaking industries to the public.

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Contents

List of Figures	viii
List of Tables	ix
1 Introduction	1
1.1 Definition, Opportunity, and Capability of IoT	1
1.2 Definition, Opportunity, and Capability of Data Analytics	2
1.3 What is Shipbreaking Industry?	2
1.4 History of Shipbreaking Industry in Bangladesh	2
1.5 Present State of the Problem	3
1.6 Standard Air Quality Index (AQI)	3
1.7 Motivation	5
1.8 Study Area	5
1.9 Research Challenge	6
1.10 Objective of the study	6
1.11 Scope of the study	7
1.12 Contribution	7
1.13 Organization of this report	8
2 Background & Literature Review	9
2.1 Background	9
2.2 Literature Review	10
2.2.1 Previous work on Air Quality Monitoring	10
2.2.2 Previous work on impact and health risk in the shipbreaking industry	13
3 Methodology	17
3.1 Sensor Layer	18
3.1.1 Circuit Diagram	20
3.2 Network Layer	21
3.3 Data Processing Layer	22
3.3.1 Cloud Server	22
3.3.2 Historical Data Processing	24

3.4	Application Layer	28
4	Implementation & Result	30
4.1	IoT Result	30
4.1.1	Device modeling and Setup	30
4.1.2	Real-time testing	33
4.2	Past Data Analysis	34
4.2.1	Environment Monitoring	34
4.2.2	Assessment of Worker's Health Condition	34
4.3	Interface	40
4.4	Discussion	41
5	Conclusion & Future Work	43
5.1	Future Work	44
	Bibliography	45

List of Figures

1.1	Air Quality Index with Health Concern	4
1.2	System Overview	6
3.1	Taxonomy of Proposed System	17
3.2	Hardware Devices	20
3.3	Circuit Diagram	21
3.4	ThingSpeak Channel Id	23
3.5	ThingSpeak API Key	23
3.6	Flowchart	29
4.1	Initial Setup	32
4.2	Final Experimental Setup	32
4.3	Sensor data representation in Cloud Server	33
4.4	IoT Past Input Data	34
4.5	Sample Input Data	36
4.6	Mean, Std, Q1, and Q3	36
4.7	Input Data Describe	37
4.8	Data Conversion	37
4.9	Target Value	38
4.10	Filter Data	38
4.11	Boxplot	39
4.12	Classification result of our model	39
4.13	Model Accuracy	40
4.14	IoT Final Output Data	40
4.15	Web Interface	41

List of Tables

2.1	Summary table of related work	14
3.1	Acknowledgement of doctors from different hospitals	26
4.1	Connection of D1 mini and DHT22	30
4.2	Connection of D1 mini and BMP280	31
4.3	Connection of D1 mini and MQ135	31
4.4	Connection of MQ2 and MQ7 with ADS1115 and D1 mini	31
4.5	Hospital Survey	35
4.6	Health Assessment of Workers in Sitakunda Shipbreaking Industry . . .	35

Chapter 1

Introduction

Bangladesh is viewed as one of the leading shipbreaking countries in the world. It is a practice that is carried out in Bangladesh's coastal regions and has grown in importance to the macro and micro-economies of the country because of its extreme poverty. This industry is vital to our country but it seriously harms the coastal environment and endangers the health of the workers. It is difficult to prevent environmental pollution in shipbreaking yards. But by taking the necessary steps, the number of pollutants can be reduced. In this chapter, we present an overview of our research work.

1.1 Definition, Opportunity, and Capability of IoT

The term IoT stands for Internet of Things, which describes the quickly expanding network of actual physical objects known as things. These devices include sensors, software, and other components built right into them, allowing them to collect data and exchange it with other systems and internet-connected devices without human contact. The IoT aims to make it possible for things and objects to be associated to everyone, anytime, anywhere, and through any network, path, or service as an enabler of Industrial Revolution 4.0. At present, IoT is utilized in various businesses, including producing, purchasing merchandise, retailing, marketing, medical care, transportation, agriculture, monitoring systems, smart cities, operations, supply chains, and so on [1][2]. It has been one of the most praiseworthy developments of rising innovation. The quick advancement of the web works with IoT to spread pervasively by interfacing the actual world with the virtual world, which additionally suggests the wide range of IoT applications going from indoor and outdoor.

IoT creates a vast network of many billions or trillions of interconnected "Things." It is the development of the latest communication modes and completes use of existing technologies, not a rebellious revolution against them. Physical items have digital equivalents and virtual representations, they learn context, sense, interact and communicate data, information, and knowledge, all of which point to a positive relationship between the physical and digital worlds. Through the use of data from the current physical environment, there are new chances to meet business needs and create new

1.2 Definition, Opportunity, and Capability of Data Analytics

services. It has the potential to connect everything, both real and virtual.

The capabilities of IoT applications include location identification and sharing, environment sensing and detection, remote health monitoring and control, tracking mobile assets, secure communication, and management, appliance control, ad-hoc networking, etc.

1.2 Definition, Opportunity, and Capability of Data Analytics

The deliberate application of logical and statistical methods to define, illustrate, gather, and assess data is known as Data Analytics, or DA. The most crucial phase of any research effort is this one. It condenses the data [3]. It entails performing an analysis of gathered data using logical and analytical reasoning in attempt to spot trends, correlations, or patterns. Machine Learning algorithms and Data Analytics approaches are used to make the data more informative.

Some of the typical prospects of Data Analytics include statistical simulations, mathematical modeling, the analysis and interpretation of numerous survey outcomes, business projections, etc.

Making precise predictions, identifying trends and outliers, and frequently informing forecasting is the capability of Data Analytics.

1.3 What is Shipbreaking Industry?

Shipbreaking is the method involved with destroying an outdated vessel for rejection or removal. It is used to characterize the most common way of separating old ships. It includes the action of eliminating reusable materials, for example, steel scraps, furniture, electronic materials, and so on, tracked down in a pre-owned vehicle. This brings down the interest in mined iron metal and diminishes energy use in the steelmaking system. Installations and other gear on board the vessels can likewise be reused. Shipbreaking is a critical process because of the intricacy of the ships' structures as well as the numerous environmental, safety, and health concerns that are involved.

1.4 History of Shipbreaking Industry in Bangladesh

In 1964, an abandoned Greek vessel was dumped in Sitakunda, Chittagong, by a neighborhood scrapyards named "Steel House". In 1974, "Al-Abbas," a rescued Pakistan Navy vessel sunk during the freedom war, was dumped in a yard in Chittagong, Bangladesh. Nonetheless, other rescued ships from the freedom war supported the dumping business. In the extended time of 1984, Bangladesh shows up as a significant ship recycling country in the world [4]. Since 1974, there have been over 50 shipbreaking yards in Bangladesh, and they have broken up about 52% of the obsolete ships over

200 deadweight tons. Despite being one of the world's largest shipbreakers, Bangladesh did not formally recognize the primary activity as an industry until 2006 [5].

1.5 Present State of the Problem

Chattogram is known as Bangladesh's business capital, with its separate present-day areas and seaport. Particularly, the shipbreaking industry inside this city is the main business of Chattogram. The improvement of the shipbreaking area has been impressively supported by worldwide financial development, which has helped overall sea exchange. At the current time, the shipbreaking business has a gigantic market all over the world. According to a report by "NGO Ship Breaking Stage (2020)", Bangladesh obtains what is happening in ship reusing in 2019 generally. As per the report, this year, 674 oceanic business ships and offshore units were proposed to the piece yards all around, and 234 of these were demolished in different ship reusing yards in Bangladesh. Of course, "Joined Countries Gathering on Exchange and Improvement (2019)" conveyed in a report named "Overview of Oceanic Vehicle 2019" that Bangladesh, in like manner, stood firm on the top traction in ship reusing. The report communicates that in 2018, the Bangladesh ship reusing industry captured the general market by obliterating around 47.2% of outright piece ships [6]. So, there is no objection that shipbreaking businesses are fundamental for Bangladesh.

Recently, Bangladesh has mostly focused on the economic benefits of shipbreaking yards while overlooking their effects on the environment. Unfortunately, these enterprises bring a lot of damage and massive natural contamination like air pollution, water pollution, soil pollution, radiation, and blasting in the seaside areas of Bangladesh. Environmental monitoring consists of such kinds of pollution. The contamination is contributed by a few factors, some of these are man-made and others because of normal causes [7]. Air contamination is given more significance than different kinds of contamination since it is the most fundamental component of every single living thing. Because of unfortunate air quality, everything living on earth is tormented with cancer, heart conditions, pneumonia, cardiovascular diseases, lung diseases, and irritating asthma. Particles (PM_{2.5}), nitrogen oxides (NO_x), sulfur oxides (SO_x), ozone (O₃), temperature, humidity, surface pressure, and dew point all contribute to environmental contamination. According to a study [8], radiation from shipping in the ocean can contribute to more than 10% of sulfur deposition in Malta (56%) and Cyprus (30%) as well as more than 10% of nitrogen removal in Malta (51%), Cyprus (30%), Greece (21%), Italy, and Cyprus (30%). The health consequence of air contamination have been evaluated exhaustively to help the setting of encompassing air quality rules by the WHO and public norms, for example, the U.S. Public Ambient AQI Standards [9].

1.6 Standard Air Quality Index (AQI)

AQI is utilized to follow everyday air quality. It is vital to gauge the extent of air toxins accessible in both indoor and outside encompassing. It gives data on how dirty

1.6 Standard Air Quality Index (AQI)

the surrounding air is and could be approaching the future. Furthermore, it illuminates us regarding any potential adverse well-being influences. The AQI was made to help individuals in figuring out what their nearby air quality means for their well-being. For 5 essential air contaminations, for which public air quality guidelines have been laid out to safeguard the Environmental Protection Agency calculates the AQI. PM is the primary air pollution connected with death and contamination diverged from other assessed rules of toxins. In the AQI, there is 3 particular molecular index that exists PM1.0, PM2.5, and PM10. The most destructive air toxin among them is PM2.5. Late assessments tracked down a recommended association between extended receptiveness to air contamination, especially PM2.5, and an extended replace of death due to the incredible bet of viral contaminations [10].

The AQI is measured on a scale from 0-500 worldwide. With rising AQI values, the degree of air pollution and related health risk rise. To better comprehend what local air quality means for our health, the AQI was created. To clarify, the AQI is separated into 6 parameters of health concerns as given below [11] –

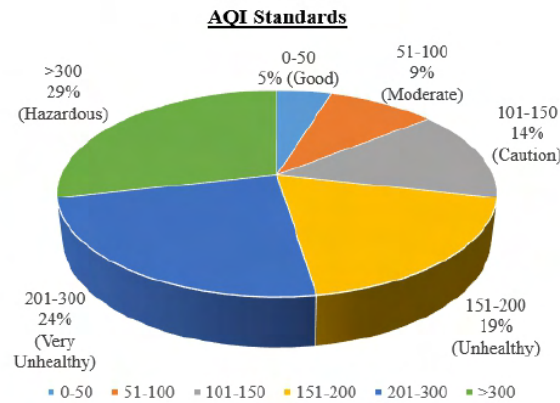


Figure 1.1: Air Quality Index with Health Concern

- **Good:** The AQI incentive for an area is somewhere the range is 0-50 which means the quality of air is good and postures have almost no well-being risk.
- **Moderate:** The AQI is somewhere in the range of 51-100 which means air quality is Ok.
- **Caution:** When AQI values are between 101-150, humans from delicate gatherings might have bad health impacts, and the general population is probably to be affected.
- **Unhealthy:** When AQI values fall between 151-200, everyone might start to encounter health effects. More severe health effects may be felt by people from sensitive groups.

- **Very Unhealthy:** The values of AQI are somewhere in the 201-300 range meaning everybody might encounter more serious well-being impacts.
- **Hazardous:** AQI values more than 300 trigger health admonitions of crisis conditions. The whole populace is significantly bound to be impacted by serious health impacts.

1.7 Motivation

Numerous mishaps happened around here for obviousness. Mishaps are common eccentricities in the shipbreaking yards for obviousness. All through the ongoing years, more than 400 experts have been killed and 6,000 were genuinely harmed [12]. Because of the conspicuousness and absence of government patronization, the activities are standing up to a couple of inside and external issues. Recently, a fire and an enormous impact killed something like 49 people and hurt 300 more on June 4, 2022, close to the city of Chittagong, Bangladesh. Numerous people made an appearance to deal with the fire when different steel trailers exploded at the site in Sitakunda [13].

Sitakunda's coastal environment is harmed by various shipbreaking-related processes, for example, the arrival of poisonous substances into the soil, the removal of different harmful materials into the sea, the getting free from trees for developing shipbreaking industries, and changes in how to land is utilized. The workspace in the shipbreaking industry is not appropriate for workers. They are expected to carry out their responsibilities in a disagreeable, hazardous climate with few offices. The exceptionally dangerous and poisonous working circumstances that these representatives are exposed to seriously endanger them for both physical and mental issues as well as face some effects like a cellular breakdown in lung cancer, esophagus cancer, asthma, various types of infections in the body, and so on.

Seeing all of these, we are motivated to do something to alleviate such kind of pollution and give alert to the people.

1.8 Study Area

We have picked the southwest piece of Bangladesh named Chattogram, as the shipbreaking enterprises in our nation are all arranged here. Chattogram city is arranged southeast of the capital city of Dhaka which is around 280 km from the capital. This city is organized on the bank of Karnaphuli and the city is surrounded by typical rich resources. Sitakunda is one of the main Upazila of the Chittagong regions in Bangladesh as the city created regarding this Upazila. This Upazila is arranged near the Straight of Bengal which makes it a sensible spot for the shipyard. Along the 7 km coastline of Selimpur, Bhatiary, Kumira, and Bar Aoulia Relationship of Sitakunda is sensible for the shipyard. This locale lies along the Dhaka-Chittagong roadways, which are 10 km away from Chittagong Metropolitan City. Once more, these districts can be related actually with the Dhaka-Chittagong freeway which makes the transportation cost of dismissing

steel astoundingly low. In any case, there are new specific clarifications behind the improvement of the shipbreaking business in Sitakunda as well as in Bangladesh.

1.9 Research Challenge

While doing our work we needed to confront a few difficulties. The fundamental test showed restraint health information assortment from hospitals as without government order any hospital cannot give their hospital data to anybody. It is difficult to gain approval to enter the shipbreaking yard as there are a few limitations. Because of the significant expense of IoT devices and the way that not all devices are accessible in Bangladesh, it was trying as far as we were concerned to make our framework precisely and affordably.

1.10 Objective of the study

To address the existing challenges at ship-breaking yards, some comprehensive plan must be established.

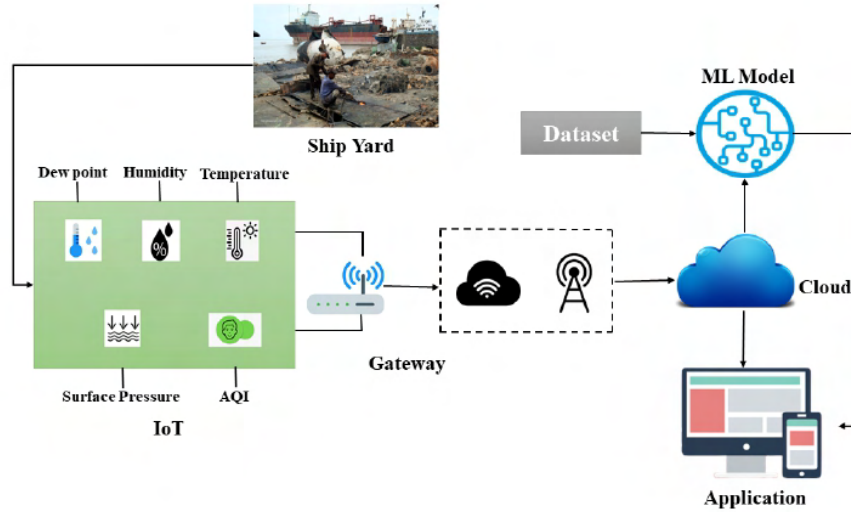


Figure 1.2: System Overview

Figure 1.2 displays the overview of the proposed system. The study's overall objectives are given below -

1. To collect real-time data and 24/7 remotely monitor the environmental quality of the shipbreaking industry using IoT technology
2. To build the model using different Machine Learning algorithms and find better accuracy

3. To observe the health condition of workers as well as general people in the ship-breaking industry and figure out the issues with respect to health impact and give some suggestions

1.11 Scope of the study

This study will serve as a new researcher's dictionary for Bangladesh's ship recycling industry and their associated environmental and social health issues. The current state of Bangladesh's shipbreaking industry will be examined in this study, along with a general overview of South Asian nations. The location of shipbreaking operations between Bangladesh and India can be compared. The study can also be used to estimate the environmental damage caused by shipbreaking operations. In the final stage of the study, some strategies and a sustainable plan will be developed for the industries involved in shipbreaking, which will be a new contribution for Bangladesh and the nations involved in shipbreaking activities.

1.12 Contribution

Some major contributions of our system are as follows -

1. Primary dataset collection by hospital survey which is completely solitary
2. Combination of 2 different sectors e.g., IoT and Data Analytics techniques
3. Outdoor environment monitoring system for the shipbreaking industry and observing the health condition of workers
4. Apply different ML algorithms with high accuracy

In our system, we have proposed a system to monitor real-time environmental pollution with 5 input features such as temperature, humidity, dew point, surface pressure, and PM 2.5 using IoT techniques. Collected data has sent and stored in a centralized cloud-based system named ThingSpeak. We have collected almost 2373 data from the last 7 years (2016-2022) from NASA Power View, air quality data from US Console, Dhaka, and the Ministry of Environment Forests, Bangladesh. Moreover, we have also made a health survey from different 6 hospitals like - Sitakunda Upazila Health Complex, Anwara Upazila Health Complex, Boalkhali Upazila Health Complex, Patiya Upazila Health Complex, Ramghar Upazila Health Complex, and Chattogram Maa-Shishu O General Hospital. As the system is built for the Sitakunda shipbreaking area, so we have made a comparison of the Sitakunda area people affected rate with other areas. From our survey, we have divided our risk factors into 3 categories such as- high, medium, and low. The Data Analytics technique is used to analyze the data and build the model using different ML algorithms. Then we have shown a comparison between historical data and real-time data with an accuracy of almost 76-82%, where the Random Forest Classifier gives the highest accuracy of 81.78%. Our overall system

is shown in the web interface. According to our research, we have observed that the environmental pollution and health condition of the shipbreaking industry area is worse than other non-industrial areas. The workers of the shipbreaking industry are seriously affected by such kind of pollution. Finally, we have tried to give some recommendations to alleviate such a problem.

1.13 Organization of this report

Introduction has been covered in this chapter. The report's remaining section is organized as follows. The previous works that are closely linked to our system were covered in chapter 2. In chapter 3, we covered our methodology and how we carried out our work. The implementation and experiment results, as well as a discussion of our work, are included in chapter 4. Finally, in chapter 5, we put an end to our work and provided a plan to extend our work in the future.

Chapter 2

Background & Literature Review

2.1 Background

Before 1960, this preparation was bound to a few industrialized countries like the US, the UK, Germany, and Italy. Throughout the course of recent many years, the shipbreaking business has stood out for giving natural substances to steel, shipbuilding, and different ventures in Bangladesh and other South Asian nations like India, China, Pakistan, Bangladesh, Turkey Philippines, Vietnam, and so on [14]. The shipbreaking business is well in front of different industries, counting the car and flight ventures, in recycling 95-98% of a ship's weight [15].

One of Bangladesh's most environmentally valuable regions is its coast, which has a variety of wildlife and includes some of the nation's native animal species. Ship-breaking is one of the greatest and most rapidly growing businesses in Bangladesh which is situated close to Sitakundu only northwest of Chittagong. In Sitakunda, there are roughly 150 shipbreaking yards, with 100 of them being functional the entire year along Sitakunda seaside locales, especially around Kumira, Bhatiary, and Fouzdarhat. Bangladesh has become a prominent player in worldwide ship recycling industry as a result of its access to inexpensive labor, government assistance, significant demand for shipwreck materials, and lack of stringent environmental regulations. Bangladesh has demolished the most ships regarding gross tonnage over the last three years, from 2016 to 2018 [16]. As per concentrates by the World Bank and Youthful Power in Social Action (YPSA), the quantity of individuals working straightforwardly at ship-breaking yards goes from 20,000 to 50,000, while the quantity of individuals utilized in a roundabout way goes from 100,000 to 200,000. According to many reports, this industry in Bangladesh is evaluated as worth a yearly turnover of 1.5 billion dollars [17]. Bangladesh has arisen as a forerunner in the reusing of old ships. These days, it is one of the expected businesses for economic improvement as it sets out different work open doors and holds huge benefits in foreign exchange.

2.2 Literature Review

In view of the framework plan and control components of frameworks inside the IoT and Data Analytics, a literature review was directed in this chapter. After broad exploration, it was found that there are various research works that use environmental monitoring as well as health condition monitoring of workers in the industry area, which help us in our project work. Here, we talk about the works that are relevant to our work in this section.

2.2.1 Previous work on Air Quality Monitoring

Puneet et al. [18] proposed a helpful device that was gifted in checking and measuring the Air Quality Index (AQI) and Particulate Matter (PM) in understanding ecological limits like atmospheric pressure, humidity, temperature, and dew point. The primary strength is air quality, too as toxin levels, can be effectively concluded by people living around there. This device could be extensively utilized in working environments, businesses, instructive establishments, neighborhoods, and so on for 24h every day. The research gap of this paper is that they took just PM matter centralization of the size in micrometers.

This article presented an overview (2015-2020) of cutting-edge IoT-based indoor air quality observing devices. The checking framework, information capacity, information investigation administrations, and information representation framework make up the design's 4 areas. This study supported the investigation and combination of key data on current frameworks. The key point of this paper is the blend of late discoveries, information gaps, related challenges, and proposed bearings for what's in store. However, the utilization of aligned sensors was the major issue [19].

This article gave an overview of the composition from 2014-2018 on the usage of data mining in the assessment of air poison assessments. The objective of this investigation was to create a once-over of the smart work done in data mining and air quality and thusly work with new devices for future works. They addressed different ways to deal with envisioning information associated with air quality. Yet, they just surveyed the responsibilities of data mining in the assessment of air quality [20].

A survey of the significant instruments that had been successfully executed for diminishing the functioning temperature of nanostructured material's temperature for low and room-temperature gas recognition was portrayed by Xiaohu et al. [21]. The modern benefit in the arrangement of useful designing for the assembling of uncommonly conduct nanostructured gas identifying propels for regular and prosperity noticing are examined comprehensively. They used nanostructured gas-detecting innovations for checking air quality, climate, well-being, and clinical areas. Less conductivity and the shortfall of selectivity were key obstacles to their pragmatic execution.

This paper [22], studied the current status of indoor air quality checking systems subject to the IoT and distant sensor networks over the latest 5 years (2014-2019). Here, 10 particular countries participated in the assessment. This file revolved around the design, networks, sensors, and microcontrollers used by these structures. The primary

contribution is to synthesize the flow collection of information and recognize continuous thoughts that are useful for future exploration. Their limits on handling capacities, sensors' precision, and energy utilization.

IoT-based Air framework proposed by Junho et al. [23], gainfully screened the air quality and sent the data to server through LTE dynamically. The contribution of the framework was created to screen air quality with continuous information productively. The framework was great exactness, is reliable, and can be gotten to from any place. However, more tests were expected to ensure information precision for long time periods. The ventilation system was absent here.

The goal of this effective survey was to present a subjective and quantitative evaluation of insignificant sensors while giving significant pieces of information into the decision principles for palatable noticing. This study [24] showed a correlation between the ongoing sensor units and really looks at progress for indoor circumstances. Highlights express examination questions, state answers, and give ideas for future investigation studies. This paper was a significant obligation to the arrangement and headway of strong, useful, and robotized Indoor Air Quality (IAQ) checking structures while making it more clear for experts to pick the best sensor units. The fundamental problem on concerning sensors' exactness, ostensible territory, reaction time, and charge examination.

Involving the AQI expectation for Beijing and the contamination focus forecast for an Italian city as specific illustrations, the authors in [25] created 2 expectation models in view of machine learning algorithms. This methodology expanded the consistency of air pointers and offered direction for recreating and inspecting metropolitan air quality. The key strength is that while both the Random Forest Regression (RFR) and Support Vector Regression (SVR) models could create great outcomes, the RFR model beats different models in tests. Nonetheless, handling a ton of tests won't function admirably with the SVR model.

Mohieddine et al. [26] proposed a framework for Indoor Air Quality Monitoring (IAQM); the system organizes distant AQ sensor center points, significant level-introduced entryways, and IoT servers. On the server, it had save and broadcast constant information. Moreover, it had information reinforcement devices at the sensor hub and entryway levels to guarantee that no information is lost if framework correspondence is lost. The principal strength is that it was giving total hardware and programming nuances of the proposed plan. However, this framework was tried exclusively in one area named Qatar College grounds.

This study joined both fixed and portable sensors that are mounted on machines that watch the region to anticipate the example of air quality around there. With this technique, the total scope of how air quality fluctuates in nearby areas might be analyzed. They inspected the forecast result from different machine models with an accentuation on PM10 and PM2.5, demonstrating the suitability and viability of their methodology. Their investigation yielded an ideal end for precise air quality observing and determining a smart city. For air quality estimating they considered little boundaries which could diminish the expectation execution [27].

The proposed deep learning model like as - Support Vector Regression (SVR) and Long Short-Term Memory (LSTM) showed a definite and express motivator for AQI in the city's foreordained region and stood out from the ongoing systems [28]. The dataset had been preprocessed to override the missing characteristics. The component extraction was finished with the use of the Grey Level Co-occurrence Matrix technique to eliminate the components. Then, at that point, the portrayal part was conveyed with the use of the significant learning framework SVR with the LSTM. The advantage of these strategies depended on the possibility that social occasion classifier expectations could prompt better class clamor discovery and was proper for input information. Likewise, utilizing a lot of boundaries and huge datasets was another benefit. But they did not utilize deep learning algorithms for improving the city's AQI values in the executives' systems.

Naomi et al. [29] introduced particular alignment models of minimal cost sensors made and supported for 16-19 Slope (Ongoing Reasonable Multi-Poison) sensors, which gauge CO , NO_2 , O_3 and CO_2 . The main strength of this article is the better exhibition of RF models using an incline screen which was unique and follows air pollution. The research gap is utilizing RF-based ML algorithms for minimal expense air quality adjustments.

In this review, occasional particulate matter estimation discoveries from the world's biggest shipbreaking yard in Gujarat, India were introduced in graphical detail [30]. The consequences of the enhancement factor and factual investigation raised the possibility that shipbreaking exercises probably significantly affected various metals. As per the discoveries of occasional circulation, the transcendent example for some metals in the shipbreaking yard ought to be the springtime pinnacle of molecule-bound metal focuses. The strength of this article is to measure the air nature of the Alang-Sosiya Shipbreaking yard and a reference terminal at Gopnath interestingly. Dismissing threats to human people, no assessments was done so far to assess the metal levels in PM, which was in like manner another strength of this article. The research gap is feeling the loss of the AQI data around there.

Chao et al. [31] broke down a positive association between CO_2 obsession and people, full-scale microorganisms, and PM focuses, checking CO_2 fixations as a normal pointer for air quality might be a pragmatic decision. The vital goal was to show the importance of the IEMS model including CO_2 as an air quality record for facility settings and illuminate clinical staff by trades structure as the air quality breaks down under an edge level. The data stage had the data following and examines abilities to give the reason for IAQ improvement measures. This framework couldn't deal with a huge volume of data.

This study presented different clinical issues taken a gander at by outside workers in Delhi that were inferable from their promise-related receptiveness to air pollution and serious environmental events. This paper suggested that the concerned Government subject matter experts and word-related government help affiliations should feature on the usage of safety efforts, making care, extemporization in the general prosperity region, and giving planning. Regardless, they didn't portray how to check the air

quality [32].

2.2.2 Previous work on impact and health risk in the shipbreaking industry

The primary goal was to give a solid foundation on which to push data about the normal influence of the shipbreaking industry and the prosperity and security issues of laborers in the business which will lead to a definite reasonableness concentrate on organization procedures for functional shipbreaking practices in Bangladesh. The ship reusing design and the limit of shipbreaking practice was their fundamental commitment. They examined numerous boundaries connected with air contamination yet AQI information wasn't depicted here [33].

Nandita et al. [34] proposed the energy-based CO_2 releases in the shipbreaking ventures in Bangladesh that showed how generally emanated from this area. By asking workers about their perceptions of whether or not they were susceptible to risks, this study hopes to learn more about the state of the workforce. The principal strength is using the Geographic Weighted Relapse model to examine the heterogeneity of the affecting factors of CO_2 spread in the shipyards. This study focused on the respondents' opinions rather than estimating the level of pollution or its adverse effects.

This paper investigated the occupation record and well-being dangers of workers who participated in shipbreaking practices at the Bhatiari, Chattogram, Bangladesh. Emotional and quantitative data were assembled through Participatory Rural Assessment devices. The main contribution is that they analyzed the livelihood guide and health conditions of shipbreaking industry laborers and gave some recommendations to boost up the health, and job conditions of laborers. Execution for such a hazardous climate was not portrayed here [35].

Taiwan was one of the world's greatest shipbreaking country, with around 65% of all old ships in the globe being destroyed there. A cohort study was carried out in this study to connect male shipbreakers with the Taiwan Cancer Registry (TCR) [36]. To investigate the hypothesis that, following a 24-year follow-up, shipbreaking employees had a higher risk of neoplasm, particularly for asbestos-related malignancies. Their primary contribution was the retrospective collection of data on 4155 male shipbreakers from the Kaohsiung Shipbreaking Workers Union database. But they only considered cancer as a risk factor.

Xiaoya et al. [37] proposed a cloud-incorporated design to oversee ecological elements, screen medical issues, survey the framework execution cycle, and execute assessment and examination from the perspective of protection and pay for negative working conditions. Their recommended plan would protect the interests of assembling laborers while improving working circumstances and carrying out well-being checking. This innovation needed unambiguous check and evaluation methods for genuine applications.

The overall previous work has been summarized in the below table.

2.2 Literature Review

Table 2.1: Summary table of related work

Title	Author	Source	Findings
IoT based air quality and particulate matter concentration monitoring system	Puneet et al. [2020]	Elsevier (Materials Today: Proceedings)	Real-time monitoring method to measure the AQI and PM concentration in understanding the environmental effects.
Indoor Air Quality Monitoring Systems Based on Internet of Things: A Systematic Review	Jagriti et al. [2020]	MDPI (International Journal of Environmental Research and Public Health)	Review from 2015-2020 on IoT-based air quality analysis to evaluate the crucial information about current systems.
Data Mining Paradigm in the Study of Air Quality	Natacha et al. [2019]	Springer Nature (Environmental Processes An International Journal)	Review from 2014-2018 on the usage of data mining for a better prediction of air contamination.
Nanostructured Gas Sensors: From Air Quality and Environmental Monitoring to Healthcare and Medical Applications	Xiaohu et al. [2021]	MDPI (Nanomaterials)	Review of mechanisms to design low-temperature, nanostructured gas sensors for air quality analysis, environmental analysis, and human health applications.
Indoor Air Quality Monitoring Systems for Enhanced Living Environments: A Review toward Sustainable Smart Cities	Goncalo et al. [2020]	MDPI (Sustainability)	Review the state-of-the-art for indoor air quality monitoring method using IoT and wireless networks from 2014–2019.
Development of an IoT-Based Indoor Air Quality Monitoring Platform	JunHo et al. [2020]	Journal of Sensors (Hindawi)	“Smart-Air” an IoT-based indoor air analysis technology that integrates cloud computing with IoT.
Sensors for indoor air quality monitoring and assessment through Internet of Things: a systematic review	Jagriti et al. [2021]	Springer Nature (Environmental Monitoring and Assessment An International Journal)	Analyzed the state of the art of inexpensive sensor technologies for IAQ monitoring.
Air Quality Index and Air Pollutant Concentration Prediction Based on Machine Learning Algorithms	Huixiang et al. [2019]	MDPI (Applied Science)	Based on ML-based regression models were built to forecast air indicators, where experiments reveal that both the SVR and RFR-based models produce good results.
A Modular IoT Platform for Real-Time Indoor Air Quality Monitoring	Mohieddine et al. [2018]	MDPI (Sensors)	Integrated wireless sensors, gateways, and IoT server were part of the disclosed modular end-to-end indoor air quality monitoring method.

2.2 Literature Review

Real Time Localized Air Quality Monitoring and Prediction Through Mobile and Fixed IoT Sensing Network	Dan et al. [2020]	IEEE Access (IEEE)	A hybrid system that used both a number of static sensors and IoT mobile sensors to detect air quality patterns.
A deep learning approach for prediction of air quality index in a metropolitan city	Janarthanan et al. [2021]	Elsevier (Sustainable Cities and Society)	Deep learning model with an accurate and precise value for the air quality index at the designated city location.
A machine learning calibration model using random forests to improve sensor performance for lower-cost air quality monitoring	Naomi et al. [2018]	EGU (Atmospheric Measurement Techniques)	Enhanced the random-forest-based ML algorithm's calibration strategies for low-cost sensing using RAMP monitors.
Heavy Metal Content of Suspended Particulate Matter at World's Largest ShipBreaking Yard, Alang-Sosiya, India	Shaik et al. [2006]	Springer (Water, Air, and Soil Pollution An International Journal of Environmental Pollution)	Seasonal particulate matter measurement finding from the biggest ship-breaking yard in the world.
Construction and Application of an Intelligent Air Quality Monitoring System for Healthcare Environment	Chao et al. [2014]	Springer (Journal of Medical Systems)	By using a wireless sensing approach and intelligence platform, an environmental monitoring prototype assessed the air quality of a public hospital.
Health impact assessment of Delhi's outdoor workers exposed to air pollution and extreme weather events: an integrated epidemiology approach	Vaishnavi et al. [2022]	Springer Nature (Environmental Science and Pollution Research)	Discussed several health issues that workers may experience as a result of their job-related exposure to air pollution and severe weather.
Impact of ship-Breaking activities on the coastal environment of Bangladesh and a management system for its sustainability	Shakhaoat et al. [2016]	Elsevier et al. [2016]	Presented how shipyard operations in Bangladesh impact the surrounding environment, the health issue, the safety of employees, and management's strategy.
Assessing Energy-Based CO_2 Emission and Workers' Health Risks at the Shipbreaking Industries in Bangladesh	Nandita et al. [2020]	MDPI (Environments)	Estimated the health threats to workers in the shipyard industries in Sitakunda, Bangladesh, and energy-based CO_2 emissions.
Livelihood Assessment and Occupational Health Hazard of the Ship-Breaking Industry Workers at Chattogram, Bangladesh	Faisal et al. [2021]	MDPI (Journal of Marine Science and Engineering)	The livelihood index and health risks of employees involved in shipyard operations in Chattogram, Bangladesh, are examined.
Cancer incidence of Taiwanese shipbreaking workers who have been potentially exposed to asbestos	Wei et al. [2014]	Elsevier (Environmental Research)	Investigated whether there is an elevated threat of cancer among male shipbreaking employees, more than 24 years up session.

2.2 Literature Review

Health Monitoring and Management for Manufacturing Workers in Adverse Working Conditions	Xiaoya et al. [2016]	Springer (Journal of Medical Systems)	Proposed a five-layer and cloud-integrated architecture for managing and monitoring the well-being of manufacturing workers.
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In the previous work, some articles worked on indoor air quality monitoring in various industries or hospitals, and some articles surveyed the affect of the shipbreaking industry on the environment or workers' health conditions. To meet up the research gap of previous work, in our proposed system we have worked on both environmental monitoring and analysis of the health condition of people in the shipbreaking industries. Here, we have combined 2 different fields such as – IoT and Data Analytics, which is not in any previous research. Our system is a low-cost real-time monitoring system and the unique dataset that we have assembled based on the particular geography of our country is the primary contribution of our study. Our system will bring new changes in our lives and beneficial ones for the people of the industry area.

Chapter 3

Methodology

A fundamental piece of work is the methodology. The procedure benefits developing a structure. Without the method, the structure improvement process is unfinished. A framework progress technique is a term that hints at the game plan or the development that is utilized to configure, all in all, controls the way toward fostering an organization. In this chapter, we talk about how to boost IoT devices, apply Data Analytics techniques, and construct different ML models to screen the ecological impact of the shipbreaking business and assess the health condition of that area's people.

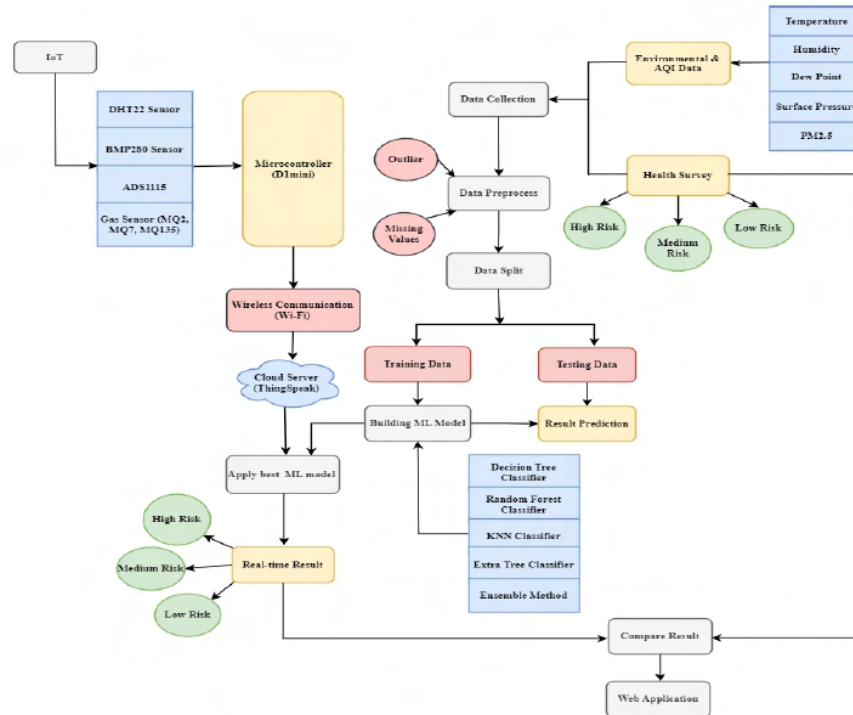


Figure 3.1: Taxonomy of Proposed System

In our system we have proposed environmental monitoring system for shipbreaking industry with health observation of workers. We divide our whole work into 4-layer architecture. The figure [3.1](#) shows the overall taxonomy of our proposed model.

3.1 Sensor Layer

In this layer we have considered 5 input features for monitoring the environmental condition of the shipbreaking industry, like as – Temperature, Humidity, Dew Point, Surface Pressure, and PM2.5.

Temperature: Perhaps the broadest and most critical actual component in an organic entity’s environmental elements is temperature. It is a check for the run-of-the-mill speed of atoms and molecules moving indiscriminately; the more noteworthy the temperature, the quicker the movement. It likewise regularly influences our overall well-being in various ways.

Humidity: We can decide the humidity by taking a gander at the dampness content, or measure of water fume, in the air. It is essential for the endurance of surface life. As well as affecting the environment, it is likewise critical for precipitation generation.

Dew Point: The temperature at which the air should be chilled to arrive at immersion is known as the dew point. It gives an estimation of the real airborne convergence of water fume. At the point when the air is completely soaked, or when the general humidity is 100%, the climate is at its Dew Point. It can be utilized as an estimating instrument to demonstrate whether it will be hot and damp or dry and decent.

Surface Pressure: Surface Pressures are the immediate natural repercussions of drivers including urbanization, horticulture, and environmental change. The wind speed and the surface pressure are firmly associated. Surface pressure, which controls worldwide breeze and weather conditions, is a critical part of the world’s environment.

PM2.5: Over the past few decades, the amount of PM, including PM10, PM2.5, and PM1.0, has significantly expanded. Due to the concentration and expansion of air pollutants, which also provide several health risks to those who breathe them in, PM has gotten worse. PM2.5 is the most significant and hazardous component of air pollution out of all of these PMs.

For collecting real-time data on the basis of the above parameters, we need some IoT hardware devices. A list of required hardware construction for manufacturing our system is described below:

D1 mini: In light of the ESP8266, the D1 mini is a Wi-Fi improvement micro-controller board viable with breadboards. Both NodeMCU and the Arduino IDE are viable with this board. Aside from pin D0, the entirety of the I/O pin supports intrude on, PWM, I2C, and wire. Open-source equipment and programming make up the D1 mini-stage. D1 mini has been used in different applications and studies. Beginners will track down it as protected and easy to use, while experienced beginners will think that it is sufficiently flexible. It has a Wi-Fi packaging module where exists an analog pin and a digital pin.

ADS1115: The ADS1115 is an Analog to Digital Converter that is very conservative, low-power, 16-bit exact, and has an inward reference voltage used for the most part in high-precision equipment, smart electronics, battery voltage, and other high-precision things circumstances.

- VDD: Power supply pin
- ALERT: Output result pin
- SCL, SDA: A way to connect with other devices

An oscillator and reference have been added to ADS1115. An appropriate I2C successive site of collaboration is used to transmit information; 4 I2C slave areas are available. The ADS1115 uses a single operational power supply with a 2.0V-5.5V range.

I2C Protocol: For our system, I2C protocol is very much essential to connect all the sensors. I2C represents an Inter-Integrated Circuit that is utilized to lay out the correspondence between at least two ICs (Integrated Circuits). It is proper for sequential correspondence convention that can associate low-speed devices. Reporting on the I2C protocol generally happens between two devices, one going about as the expert and the other as the slave. The ADS1115 conveys through an I2C interface.

DHT22: For measuring temperature and humidity we have used this sensor. The DHT22 is a minimal-expense mechanized temperature and tenacity sensor which works as a digital sensor. It utilizes a capacitive wetness sensor and a thermistor to check the air and allows a mechanized sign on the data to stick. Its functioning temperature is 40-80 degree celsius, yet can acknowledge that its communicated precision of 0.5C is simply achieved around the focal point of this range. DHT22 is simple to use anyway requires mindful timing to get information. Both are 16-digit, nonetheless, are sent 8-bit at the same time. We use it for estimating the temperature, humidity, and dew point of the environment.

BMP280: For estimating the surface pressure of the environment we have used this sensor. BMP280 is a barometric pressure especially expected for flexible applications. It works as an I2C protocol. This module is housed in an extremely modest group. Its little viewpoints and its low power usage consider the execution in battery-driven contraptions like cell phones, GPS, watches, and so on. This sort of barometric strain utilizes an aneroid cell that develops when the pneumatic stress covers it. It gives the most essential flexibility to the maker and can be changed in accordance with the necessities concerning assessment time, precision, and power usage by browsing endless expected blends of the device settings. We use it for estimating the surface pressure of the environment.

Gas Sensor: A gas sensor perceives the presence or gathering of gases in the environment, and works as an analog sensor. The sensor transmits a glance at potential conditions by varying the resistance of the substance inside the sensor, which may be estimated as the subsequent voltage, taking the mixing of the gas into account. The kind and collection of the gas can be assessed in light of this voltage concern. The chemical resistor's ability to lead current determines a gas sensor's maximum ability to detect gases. A standard gas sensor contains 4 workstations, including -

- Vcc: Power provider pin
- GND: Power provider pin
- Digital output: Either high or low (0 or 1) pin
- Analog output — Provides a constant voltage output

There is various gas sensor. The MQ2 - is used to recognize LPG, I-butane, methane, alcohol, Hydrogen, and smoke in city and industry areas, and MQ7 - recognizes the presence of Carbon Monoxide (CO) at obsessions from 10 to 10,000 ppm, and MQ135 - which can distinguish gases like Alkali (NH_3), Carbon dioxide (CO_2), Benzene (C_6H_6), Sulfur (S), and other damaging gases. For calculating the PM2.5 in the air these three sensors have been used in our system. For indoor reasons, one gas sensor is sufficient to monitor air quality. But, for an outdoor reason, one sensor isn't adequate on the grounds that one sensor has a responsiveness range of 1 meter, so an organization of sensors must be conveyed to screen the outdoor air quality [38]. We use these sensors for measuring the PM2.5 in our selected area.

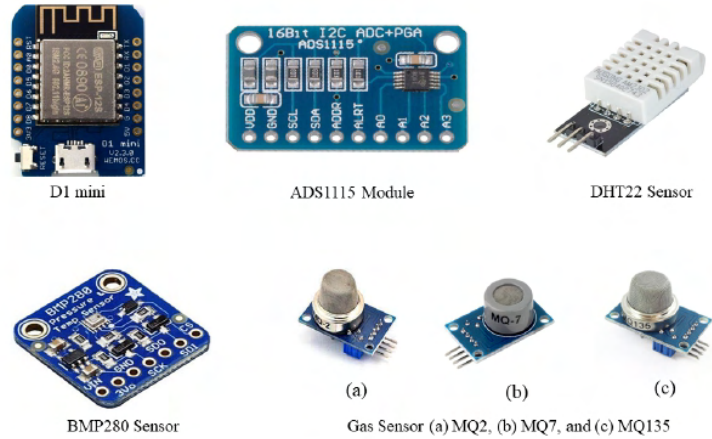


Figure 3.2: Hardware Devices

The above figure shows the all-hardware devices, like as – D1 mini, ADS1115 Module, DHT22 Sensor, BMP280 Sensor, MQ2 Sensor, MQ7 Sensor, and MQ135 Sensor, which has been used in the proposed system.

3.1.1 Circuit Diagram

By using the above hardware devices, we have prepared our circuit diagram, which shows in figure [3.3]. In the breadboard, we have connected the D1 mini, ADS1115, MQ2, MQ7, MQ135, DHT22, and BMP280 by using many jumper cables. I2C protocol has

been used for connecting all pins with the sensors. Finally, we have connected the D1 mini to the laptop using a power cable or hub, or power bank and connect over Wi-Fi protocol.

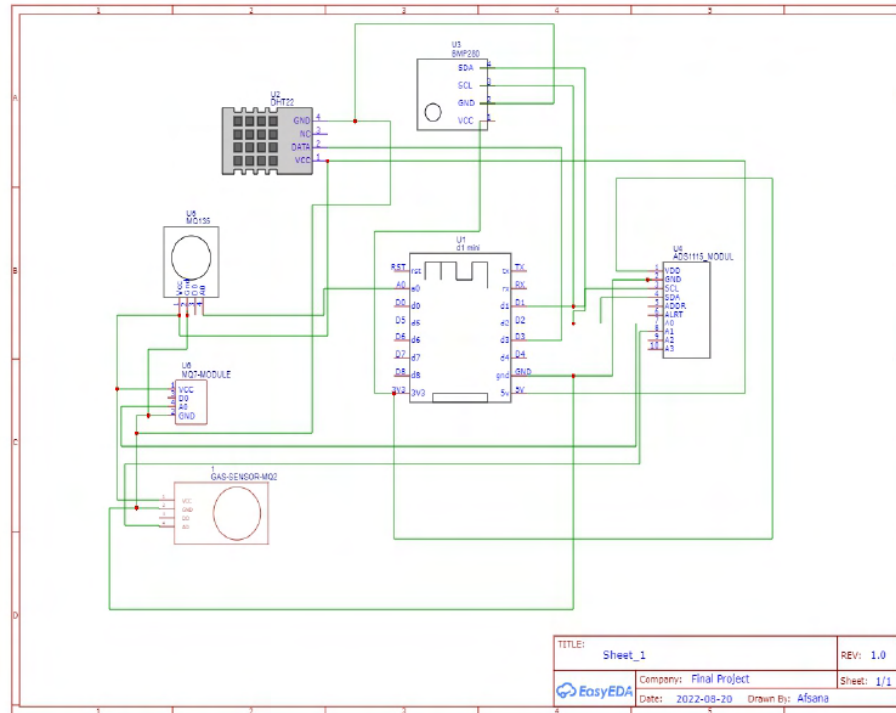


Figure 3.3: Circuit Diagram

3.2 Network Layer

Network layer is an inter-media between sensor data and the central server. In this layer, we have used a Wi-Fi protocol system and router as an IoT gateway system that directly transfers data over the cloud.

After setup the hardware devices we need to do programming in the Arduino IDE. It is an free-source programming, hardware, and client area that designs and provides single-board microcontroller units for creating electrical devices and cunning things that can recognize and manage problems in both real life and virtual one. We need to download and install the Arduino software to conduct our investigation.

Our main research tool is a microcontroller board called D1 mini that is ESP8266 Wi-Fi based, which has to configure for run the code and connect Wi-Fi. The procedures that must be taken to configure the Di Mini with the Arduino software are listed below -

- First of all, need to install the driver of CH40
- Install another package into Arduino IDE named ESP8266 Board Manager
- Install the ESP8266 Library
- Install Adafruit ADS1X15 packages for ADS1115
- Install Adafruit BMP280 packages
- Also, install Wi-Fi manager for Wi-Fi connectivity
- Then, plug in D1 mini with laptop/pc by USB cable
- Write programming
- Finally, verify and upload the code

3.3 Data Processing Layer

In this layer there are 2 parts, such as – Cloud Server, and Data Processing, which briefly describe below.

3.3.1 Cloud Server

Using IoT sensors we have collected real-time data and over the Wi-Fi connectivity send these data to the cloud. Cloud Computing empowers adaptable and productive focal use and the executives of administrations. IoT can deal with, store, and interact with such huge measures of information due to the cloud's handling power and capacity abilities [39].

In our work, we have used ThingSpeak as central server. ThingSpeak is a sort of cloud-based server for the IoT that empowers the improvement of sensor recording applications, region-following applications, and a relational association of items with takes notes. ThingSpeak incorporates the capacity to [40] -

- Design the devices to send information to ThingSpeak Easily utilizing the web.
- Imagine any sensor data in real-time on a screen.
- Total information on request from third-party.
- MATLAB is utilized to appear to be legit the IoT information.
- IoT investigation because of timetables or occasions.
- Model and fabricate IoT frameworks without creating web programming.

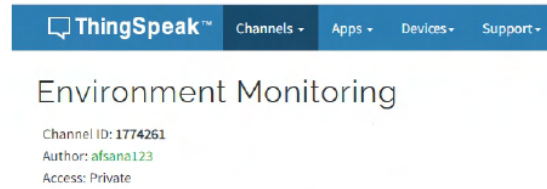


Figure 3.4: ThingSpeak Channel Id

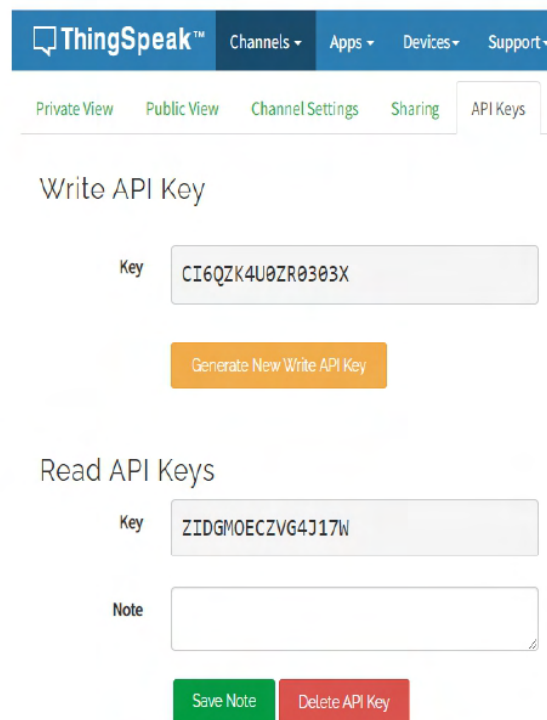


Figure 3.5: ThingSpeak API Key

Firstly, to access this server we have to generate an account on ThingSpeak. After account creation, we have to select "new channel" and complete the fields we desire, including "name," "description," and "field." Then we need to send data to this server. We receive a "Channel ID," "API Read Key," and "API Write Key" after creating a channel. The information must then be incorporated into both Arduino and Python code. Using the API key, users can access the data streaming on the ThingSpeak cloud. By using this channel, we have stored our real-time data to the cloud.

3.3.2 Historical Data Processing

Data Analytics or Analysis is an important technique which use to sort out and decipher data, then structure that data into respectable information for real-time applications. In our system, we use Data Analytics techniques to find valuable information by accessing data, displaying, and analyzing data that helps decision-making. This paradigm offers a systematic working technique that can aid in the investigation of environmental pollution analysis as well as observing the health condition of workers. This part is categorized into following 4 phases:

Phase 1. Data Collection

Environmental and AQI Data: At first, we have collected 2373 past data from January 2016 to June 2022 (7 years). Our past environment data, like - temperature, humidity, dew point, and surface pressure has been collected from “NASA Power View”. The link to the site is-

(<https://power.larc.nasa.gov/data-access-viewer/>)

Our past AQI data (PM2.5) has been collected from “US Console Dhaka”. By registering on this site, we download the AQI dataset. Also, we have found our AQI data from the “Ministry of Environment & Forests, Bangladesh”. To quantify a few substances, a “Constant Air Monitoring Station (CAMS)” is controlled by the “Environment Department under the program of Clean Air and Sustainable Environment” in Chattogram. The Chattogram TV channel camps in Khulshi, which are on a peak around 2.5 km northwest of the midtown and around 100 meters over the encompassing district, are where the CAMS is found [41]. The site links are-

(<https://bd.usembassy.gov/air-quality-data-information/>)

(http://case.doe.gov.bd/index.php?option=com_contentview=categoryid=8Itemid=32)

Health Survey Data: By doing a field survey, we have collected health data of Sitakunda area people. The collection of health surveys is the most challenging part of our system. Because the patient data is too sensitive, most of the doctors are not willing to talk with us if they are not familiar with us, as well as without a government order it is restricted to give anyone the hospital register book. Besides this, it has been very difficult to talk with anyone because workers and other relevant officers are not allowed to discuss what occurs in these places. Most of the people have refused to face interviews or give information out of fear of losing their job. Though it was so much difficult but we tried our best effort for doing this survey and finally we have collected some data for our research.

First of all, by taking a recommendation letter from our supervisor we went to Chittagong Medical College Hospital (CMCH). They informed us that they only enter the patients’ names and histories but they are not listing the area-wise patient. The Head of the CMCH suggested going to Sitakunda Upazila Health Complex and referred us to the HMO of that hospital. Then we went there and talked to HMO and he informed us that as it is a government hospital so without a government order, he would not able to give us any register books from the previous year but he gave us

permission to make a doctor's survey. So, we talked with some doctors, made a doctor's survey and collected past years' patient history and overall patient situation of there. According to them, in the Sitakunda area, most of the patients are affected by fever, breathing problems, and lung cancer, and most of the patients are adult males. This rate is high (almost 80%) in the winter season, medium (almost 60%) in the summer season, and low (almost 40%) in the rainy season. Then we made another survey in the Anwara Upazila Health Complex. By going there and talking with the doctor, we found that fever, breathing problems, and cancer patient percentage is 30-40% and most of the patients are children and the rate is high in the winter season, medium in the summer season, and low in the rainy season. Afterward, we went to the Boalkhali Upazila Health Complex, Patiya Upazila Health Complex, and Ramghar Upazila Health Complex. In the same procedure, we conducted a doctor's survey and collected the patient history in that area. In those hospitals, we found the almost same situation (20-30%) as Anwara Upazila Health Complex. Again, we went to Chattogram Maa-O-Shishu Hospital (CMOSH). As it is one of the top private medical hospitals in the Chattogram division and the admitted patient number is too high, so we choose it. From this hospital, we collected the register book by taking permission from the Head of the Medicine Department and the Head of the Oncology Department. We listed the people's numbers and health conditions in the different areas. In this hospital, we also found that the affected rate is 30-40% inside the city area and the maximum patient is children. We also noticed that the maximum number of lung cancer patients is from the Sitakunda area. As resident exposure to air pollution in huge urban communities can bring about high fever, breathing issues, asthma attacks, lung cancer, heart illness, or chronic bronchitis, so we considered these issues for our survey.

In our whole survey, some doctors from different hospitals helped us very much. Without their help, it would not possible for us to complete our health survey. Table 3.1 shows the acknowledgment of doctors who supported us by providing patient data.

Table 3.1: Acknowledgement of doctors from different hospitals

Hospital Name	Doctor Name
1. Sitakunda Upazila Health Complex Sitakunda, Chattogram	1. Dr. Asif Mohammad Shadman Medical Officer 2. Dr. Umme Salma Nishat Medical Officer
2. Anwara Upazila Health Complex Anwara, Chattogram	3. Dr. Mohammad Faisal Medical Officer 4. Dr. Sadia Tabassum Medical Officer
3. Boalkhali Upazila Health Complex Boalkhali, Chattogram	5. Dr. Israt Hossain Nawshin Medical Officer
4. Patiya Upazila Health Complex Patiya, Chattogram	6. Dr. Shamiha Rowshan Mou Medical Officer
5. Ramgarh Upazila Health Complex Khagrachhari, Chattogram	7. Dr. Falguni Das Medical Officer
6. Chattogram Maa-O-Sishu Hospital Agrabad, Chattogram	8. Dr. Fahmeda Sanji Puspa Medical Officer 9. Dr. Fhamida Jahan Gazi Medical Officer 10. Dr. Amit Saha Shuvo Medical Officer

After collecting all experimental data, we have imported the dataset into Google Colab and write code using the python programming language. Collaboratory or "Colab" is a thing from Google Exploration. We have used Colab on the grounds that it licenses anybody to create and execute conflicting python code through the program, and is especially suitable for artificial intelligence, data examination, and preparation.

Phase 2. Data Preparation

Next, we have preprocessed data and select features using the conversion method. We also have found missing values and distinguish the outlier using a boxplot while a correlation examination has been completed.

Phase 3. Build ML Model

Then, we have constructed the prediction models and figure out the best accuracy of our model based on different ML algorithms, which are detailed below:

Decision Tree Classification: Decision Tree Classification is a kind of Supervised ML technique that can be utilized to solve classification and regression problems. The data is continuously separated based on a certain parameter in this classifier, which has a tree structure [42]. The two parts of the tree that can be utilized to explain it are nodes and leaves. The leaves stand in for the outcomes. At the decision nodes, the data

is partitioned. It consists of nodes and branches. There are three further categories of nodes: leaf nodes, decision nodes, and root nodes. Each node in the decision tree uses only one independent variable to split into two or more branches because it is set up in an if-else design. It makes no difference whether the independent variable is continuous or categorical. For continuous variables, the classes generate several threshold values that act as the decision-maker; for categorical variables, the categories are employed to decide the node split.

Random Forest Classifier: Random Forest (RF) Classifier is also same as Supervised ML technique that is frequently employed in classification and regression issues [43]. In order to increase predictive accuracy and decrease over-fitting, it constructs decision trees on various samples and employs their maximum vote for classification and average of regression. A random forest technique is made up of many decision trees. A group of decision trees that were frequently trained using the "bagging" method invent the "forest" that it constructs. The bagging technique's core tenet is that joining learning models enhances the outcome [44]. Based on the predictions provided by the decision tree, the decision is decided by the random forest algorithm. It produces forecasts by averaging the results of trees. With more trees, the accuracy of the outcome improves.

KNN: K-Nearest Neighbor (KNN) is another Supervised ML technique. Although regression and classification problems can both be addressed with this strategy, the former is more frequently a problem. Being a non-parametric cycle, it makes no pre-suppositions about the fundamental data. The technique is otherwise called a lazy learner since it saves the training dataset as opposed to gaining from it quickly [45]. As an alternative, it does a task while classifying data using the dataset. The entire training dataset is searched for the k-most close examples when an unknown data instance needs a prediction, and the data with the closest example serving as the prediction is then returned [46]. By selecting the class with the highest frequency out of the K-most comparable occurrences, the outcome of classification using a K-NN algorithm can be quickly ascertained. The class with the most votes is taken into consideration for the prediction.

Extra Tree Classifier: An ensemble ML technique called Extra Trees Classifier (Extremely Randomized Trees Classifier) makes use of decision trees. The way the decision trees in the forest are built is the way it varies from a random forest classifier. It resembles a random forest classifier somewhat. Using the training dataset, this method generates a huge number of decision trees. These results are averaged to produce regression predictions, while majority voting is used to produce categorization predictions. The original training trial is used to construct each decision tree in the Extra Trees Forest. At each test node, a random sample of k features from the feature set is supplied to every tree, allowing it to divide the data in accordance with particular mathematical specifications [47]. A significant number of de-correlated decision trees are assembled as a result of this random feature sampling. The normalized entire decrease in the mathematical basis used to decide which features to split is calculated to carry out feature selection using forest structure. When choosing features, the user

picks the upper k features based on preferences after placing each feature in descending order of priority.

Ensemble Method: The ensemble methodology, an ML technique, combines multiple base models to create a single, ideal predictive model. Let's take a step back and consider the purpose of machine learning and model building in order to better comprehend this idea [48]. It works by integrating the mapping expertise acquired by the contributors. The combination of decision trees gives the best understanding of ensembles for classification. The combination of member hyperplanes also offers the best understanding of ensembles for regression.

Phase 4. Data Visualization

The creation of reports and visualizations to emphasize the outcomes of the earlier procedures is the last phase of data visualization. In this phase, we have applied several ML model, where we have found the best accuracy for our system.

3.4 Application Layer

From the test dataset, we have predicted the dependent variable, which is the risk factor (health condition) as it is our main output feature. The resulting output enables visualization of 3 categories on the basis of time series, such as -

- For high health risk display – 2
- For medium health risk display – 1
- For low health risk display - 0

A specific method for examining a group of data points gathered over schedule is called a time series analysis. Rather than simply catching the data of interest indiscriminately, time series analyzers record them at normal spans throughout a preset time. Tracking some features like trend, seasonality, and variability can be done using time series analysis. From the field survey, we have got an output (risk factor). We also have found this risk factor from our system based on IoT technique. Then, cross match both results and have found the same result.

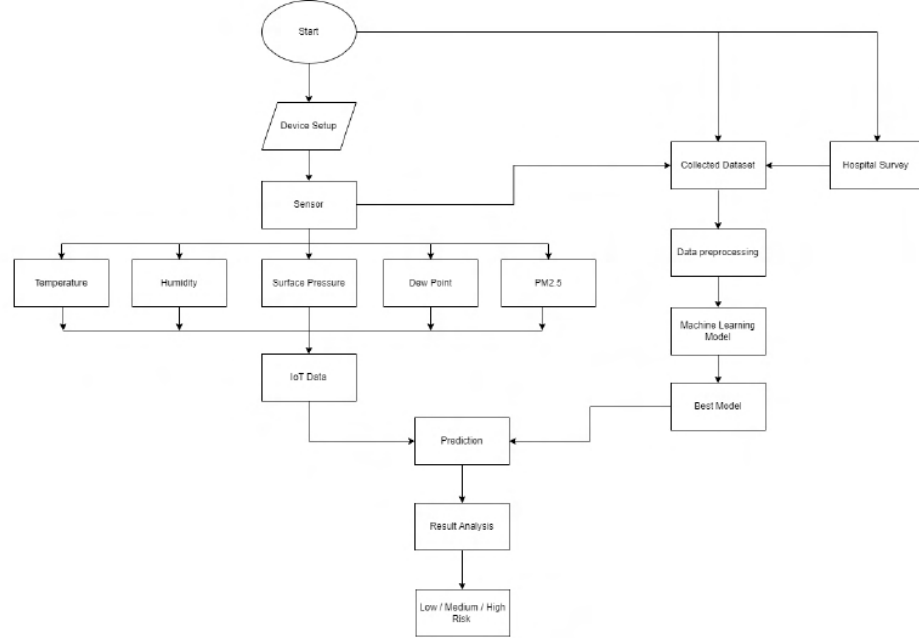


Figure 3.6: Flowchart

Figure 3.6 shows the flowchart of our overall proposed system. In this system, we have setup IoT devices and read the real-time value of temperature, humidity, surface pressure, dew point, and PM2.5 from IoT sensors. Cloud server named ThingSpeak is used to store data and retrieve data. Also, past data has been collected from different sites and have conducted a hospital survey to assess the health condition of workers in the Sitakunda shipbreaking industry. Data Analytics technique has been applied for preprocessing data, classifying the model, and finding the best model. Using various ML algorithms predict the best accuracy and analysis of the risk factor is high, medium, or low. Finally, the overall system has been displayed in the web application.

Chapter 4

Implementation & Result

We discuss about how the system is basically implemented and the experimental result of our system in this chapter. The experimental setup and system implementation go through several stages. The sensor transmitting data, getting data, implementing algorithms with testing accuracy, and the current position of the system are examined and shown below.

One of the most devastating natural disasters to have hit the planet is climate change. Bangladesh is a subtropical country in South Asia with a climate that is characterized by high summer precipitation and low winter precipitation. We choose Bangladesh's southeast coastline region since it is a prominent location for the ship-breaking industry. This region had some unfavorable natural disasters over the preceding 10 years as a result of the climate issue. Our experimental result is divided into 2 fields –IoT and Data Analytics based. Both of these results are described below.

4.1 IoT Result

In this part we work with hardware devices, set up these devices, store data, and retrieve data.

4.1.1 Device modeling and Setup

In our model, we have used D1 mini with ESP8266 microcontroller which is built-in Wi-Fi with IEEE 802.11 features. DHT22 has been used for measuring temperature, Humidity, and Dew point.

Table 4.1: Connection of D1 mini and DHT22

D1 mini	DHT22
5 volts	VCC
GND	GND
D3	Out

And the surface pressure is getting from BMP280 which is also an I2C protocol. We have used BMP 280 as the slave device and used 0X76 as the registered address.

Table 4.2: Connection of D1 mini and BMP280

D1 mini	BMP280
3.3 volts	VCC
GND	GND
D1	SCL
D2	SDA

The next parameter is AQI and for these, we have used three different sensors of Air Quality named MQ2, MQ7, and MQ135.

As the D1 mini has only one analog sensor, we have featured one sensor directly to the D1 mini and the other two have been featured with the help of ADS1115.

Table 4.3: Connection of D1 mini and MQ135

D1 mini	MQ135
5 volts	VCC
GND	GND
A0	A

The connection of MQ2 and MQ7 has been given below with ADS1115 and D1mini.

Table 4.4: Connection of MQ2 and MQ7 with ADS1115 and D1 mini

D1 mini	ADS1115	MQ2	MQ7
5 volts		VCC	VCC
3.3 volts	VCC		
GND	GND	GND	GND
	A1	A	
	A0		A
D1	SCL		
D2	SDA		

This device is mainly based on the I2C protocol where in the BMP sensor it is used as the 0X76 register and others used as the default register of every sensor. DHT22 has been used for the parameters of Temperature, Humidity, and Dew Point, and for AQI we have used three types of Gas sensors to identify the AQI of the present area which is Sitakunda.

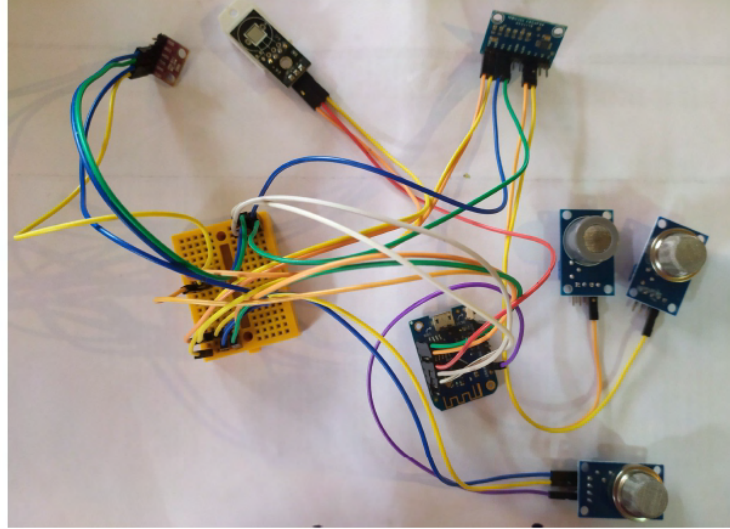


Figure 4.1: Initial Setup

Figure 4.1 indicate the initial device setup for the system. After setting all sensors we have connected our model to a laptop/pc using cable and connect the Wi-Fi. After making connection, we have run the code, compile, and upload it to the cloud server called ThingSpeak. Thus, our whole system works and measure the air quality values.

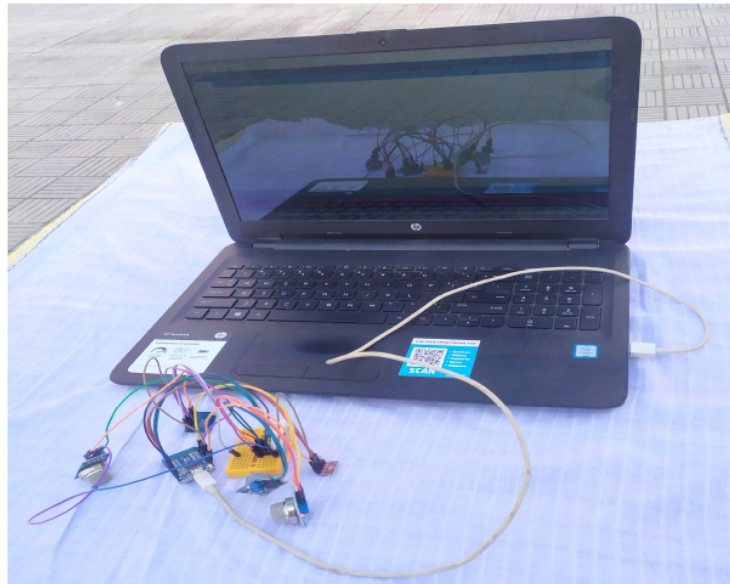


Figure 4.2: Final Experimental Setup

Figure 4.2 is the final experimental setup of our proposed model.

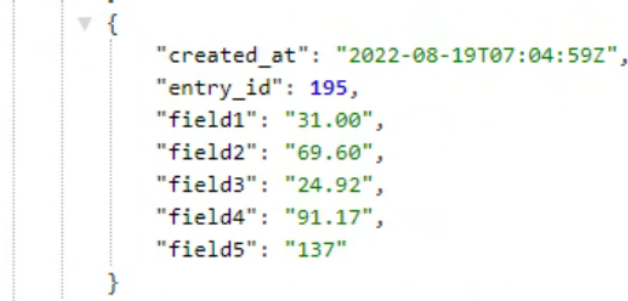
4.1.2 Real-time testing

Utilizing IoT sensors, we have collected real-time data from specific locations and taken our sensors to various circumstances to see how much data we get from our device. The sensor readings have been checked in the wake of gathering our structure. In the wake of associating with the devices, we have run our code. Sensors send data to our microcontroller and ensuing to dealing with data which will be shipped off the cloud server named “ThingSpeak”. Using the API key, users can view the data streaming on the ThingSpeak server. The most recent data or all previous data can be seen here.



Figure 4.3: Sensor data representation in Cloud Server

Figure 4.3 shows the real-time data representation utilizing IoT sensors in the ThingSpeak server. Here, “field1” represents the “Temperature”, “field2” represents the “Humidity”, “field3” represents the “Dew Point”, “field4” represents the “Surface Pressure” and “field5” represents the “PM2.5”.



```
{
  "created_at": "2022-08-19T07:04:59Z",
  "entry_id": 195,
  "field1": "31.00",
  "field2": "69.60",
  "field3": "24.92",
  "field4": "91.17",
  "field5": "137"
}
```

Figure 4.4: IoT Past Input Data

The last and final data uploaded to the ThingSpeak server is shown in figure [4.4](#). In this server, we have stored our real-time testing dataset.

4.2 Past Data Analysis

We have collected the last 7 years' data from January 2016 to June, 2022 our framework. We have considered both secondary and primary data for our implementation. Outdoor locations have been chosen because our system is related to industrial areas.

4.2.1 Environment Monitoring

We have collected past environmental datasets from different authentic sites, like - NASA Power View, US Console Dhaka, and Ministry of Environment & Forests, Bangladesh. This is our secondary dataset. By using this dataset, we monitor the environmental pollution in the shipbreaking industry.

4.2.2 Assessment of Worker's Health Condition

One of the major contributions and challenges part of this system is our primary dataset. For collecting this dataset, we have made a hospital survey to assess the health condition of workers in the shipbreaking industry. We have visited 6 different hospitals and talked with some doctors and tried to collect patient register books to collect patient data. After collecting the dataset, we have compared these 6 different hospitals' patient-affected rates. And, from these health surveys, we have found that the patient rate is too high in the Sitakunda area which means industrial areas compared to the non-industrial areas. We also have noticed that in the industrial area, most of the affected people are male adults whereas, in the non-industrial area, the maximum patient is children. The complete survey hospital list and survey outcome are shown in the below table.

Table 4.5: Hospital Survey

No	Hospital Name	Infected Patient Rate	Maximum Patient Category	Industrial Area	Status
1.	Sitakunda Upazila Health Complex	60-70%	Adult Male	Yes	High Risk
2.	Anwara Upazila Health Complex	30-40%	Child	Yes	Medium Risk
3.	Boalkhali Upazila Health Complex	20-30%	Average	No	Low Risk
4.	Patiya Upazila Health Complex	20-30%	Average	No	Low Risk
5.	Ramgarh Upazila Health Complex	20-30%	Average	No	Low Risk
6.	Chattogram Maa-O-Shishu Hospital	30-40%	Child	No	Medium Risk

According to the survey, we realize that in the shipbreaking industrial areas, the workers are affected badly and environmental pollution is responsible for that. For our final experiment, we have considered Sitakunda Health Complex hospital data as our research field in the Sitakunda area. We also have categorized our dataset into season bases. The result of the overall health condition of the Sitakunda area is given below.

Table 4.6: Health Assessment of Workers in Sitakunda Shipbreaking Industry

Hospital Name	Time-series Analysis	Maximum Patient Category	Infected Patient Rate	Risk Factor
1. Sitakunda Upazila Health Complex	Winter Season	Adult Male	70-80%	High
	Summer Season	Adult Male	40-50%	Medium
	Rainy Season	Adult Male	20-30%	Low

According to this health assessment, we have found that in the shipbreaking industry, people are affected very much in the winter season as air pollution is much longer than in any other season. For further processing, we have classified our output dataset (risk factor) into 3 categories, such as - high-risk factor for the winter season, medium-risk factor for the summer season, and low-risk factor for the rainy season, according to time-series analysis.

4.2 Past Data Analysis

From the above site and process we have collected our historical dataset. Then, we have combined our whole dataset for further processing. In figure 4.5 shows the overall sample input dataset for our research.

[5] inputData

	Date	Temperature	Humidity	Dew Point	Surface Pressure	PM2.5	Risk Factor
0	1/1/2016	19.52	74.12	14.58	101.50	176.0	High
1	1/2/2016	19.80	71.12	14.19	101.40	179.0	High
2	1/3/2016	19.48	70.81	13.73	101.29	181.0	High
3	1/4/2016	19.04	72.50	13.77	101.33	174.0	High
4	1/5/2016	18.82	73.75	13.77	101.29	178.0	High
...	...	...	...	...	...	...	...
2368	6/26/2022	28.23	84.94	25.37	100.08	92.0	Medium
2369	6/27/2022	27.94	87.76	25.68	100.17	73.0	Medium
2370	6/28/2022	27.94	84.44	25.01	100.09	74.0	Medium
2371	6/29/2022	28.38	84.69	25.48	99.93	98.0	Medium
2372	6/30/2022	28.00	88.19	25.83	99.89	117.0	Medium

2373 rows x 7 columns

Figure 4.5: Sample Input Data

We have collected sample input datasets for analysis of the environmental pollution and health observation of workers, where the risk factor is the dependent variable and temperature, humidity, dew point, surface pressure, and PM2.5 are the independent variables. We have preprocessed our input dataset. We have detailed our datasets after taking input data to find outliers and significant features. Due to this, we have calculated the values of our independent and dependent variables' means, standard deviations, minimums, Q1, Q2, Q3, and maximums, which display in figure 4.6.

inputData.describe()

	Temperature	Humidity	Dew Point	Surface Pressure	PM2.5
count	2373.000000	2373.000000	2373.000000	2373.000000	2302.000000
mean	25.472292	79.984231	21.455765	100.472975	136.632493
std	3.847374	9.567632	4.907882	0.494595	70.299135
min	13.640000	44.380000	8.510000	98.820000	13.000000
25%	22.730000	74.620000	17.260000	100.090000	85.000000
50%	27.260000	82.190000	23.430000	100.500000	119.000000
75%	28.300000	87.750000	25.760000	100.890000	185.000000
max	31.780000	94.690000	27.300000	101.510000	1224.000000

Figure 4.6: Mean, Std, Q1, and Q3

Figure 4.7 shows the graphical statistics of our input dataset.

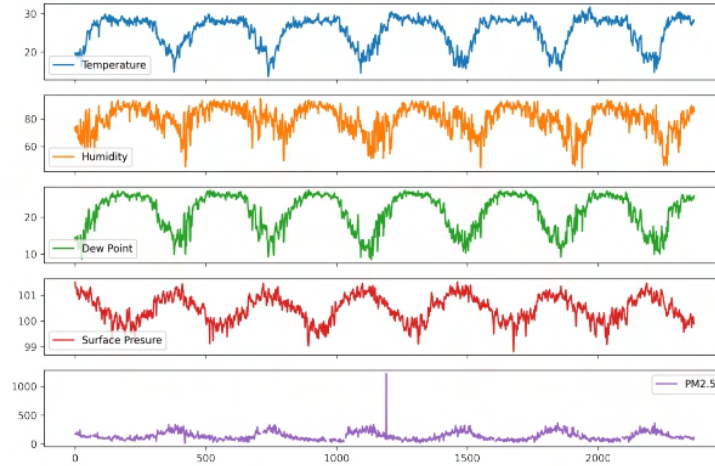


Figure 4.7: Input Data Describe

Feature selection has been done using the conversion method. We have used the conversion method for feature selection. The data conversion method is utilized to change data into a different format. In order to conversion method, data first be taken from its source in order to be transformed. The data can be transformed into the format required by the system or database where it will be stored. The data must be loaded into the target value. Our collected dataset is a categorical value, so we have used the conversion method to convert it into an integer value.

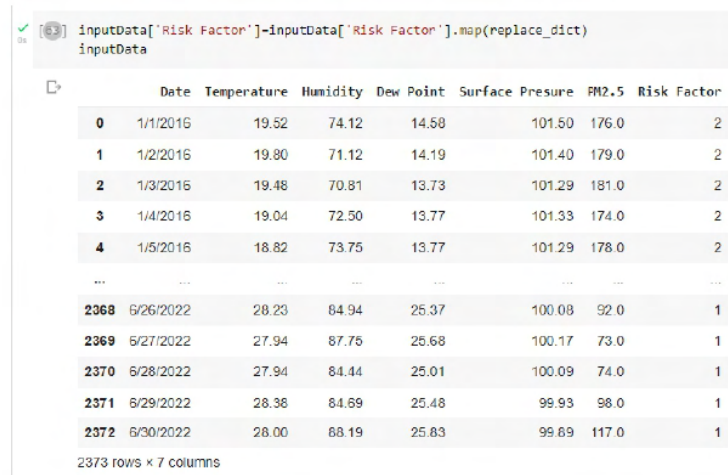


Figure 4.8: Data Conversion

Our target value is the risk factor, which has been converted into an integer value. Here, we have drawn a plot bar to display our target value (risk factor), where the value “2” represents “high”, “1” represents “medium”, and the value “0” represents “low”.

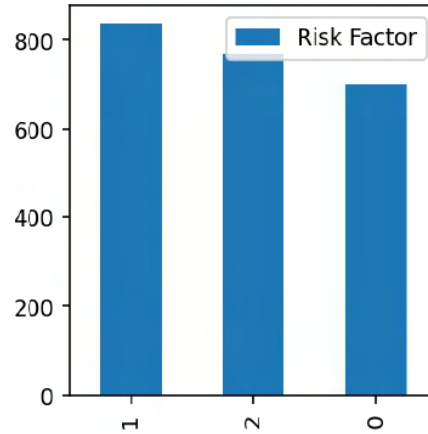


Figure 4.9: Target Value

Then, we have counted the number of noise or missing values in our dataset in order to preprocess it. Then, in order to prevent the model from being disturbed by any uncertain noise, delete all the missing data and outliers from our datasets. Outliers make data more variable, which reduces statistical power. Here, our original data has been 2373; however, after filtering the whole dataset we have found 2302 data with 5 independent variables and 1 dependent variable.

✓ [72] x

	Temperature	Humidity	Dew Point	Surface Pressure	PM2.5
0	19.52	74.12	14.58	101.50	176.0
1	19.80	71.12	14.19	101.40	179.0
2	19.48	70.81	13.73	101.29	181.0
3	19.04	72.50	13.77	101.33	174.0
4	18.82	73.75	13.77	101.29	178.0
...	...	...	...	...	...
2368	28.23	84.94	25.37	100.08	92.0
2369	27.94	87.75	25.68	100.17	73.0
2370	27.94	84.44	25.01	100.09	74.0
2371	28.38	84.69	25.48	99.93	98.0
2372	28.00	88.19	25.83	99.89	117.0

2302 rows x 5 columns

Figure 4.10: Filter Data

Boxplot has been used to include outliers for each independent variable, such as – temperature, humidity, surface pressure, dew point, and PM2.5.

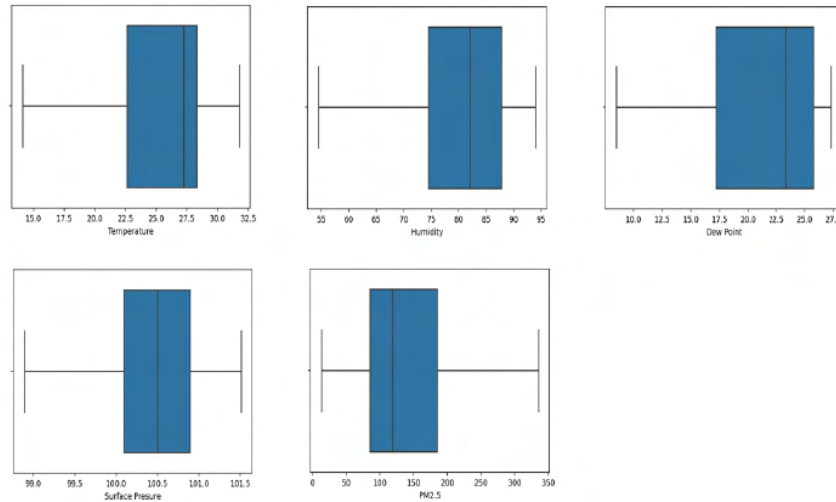


Figure 4.11: Boxplot

We have divided our dataset into training and testing. 70% of the actual data are in the training data set, and the other 30% are in the testing data set. Training datasets are required to create prediction models, and testing datasets are required to assess the model's effectiveness. Then, we have applied different ML algorithms, e.g., Decision Tree Classification, Random Forest Classifier, KNN, Extra Tree Classifier, and Ensemble Method for finding the best accuracy.

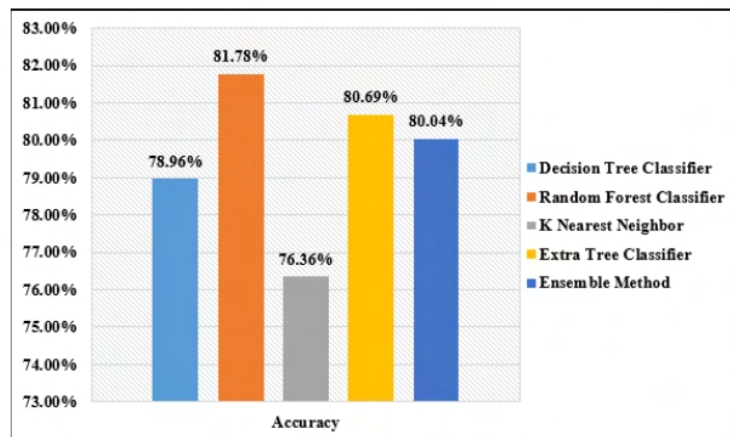


Figure 4.12: Classification result of our model

After implementation, we have discovered that our dataset has good accuracy, al-

lowing us to predict the desired results. Figure 4.12 represent the accuracy of all implemented algorithms. Among all of these, the Random Forest has given the best accuracy of 81.78%. The highest accuracy of our model has been showed in figure 4.12

```
[ ] from sklearn.metrics import accuracy_score
    a=accuracy_score(y_test,pred1)
    print("The accuracy of this model is: ", a*100)

The accuracy of this model is: 81.77874186550976
```

Figure 4.13: Model Accuracy

In the previous, we have uploaded real-time data to the ThingSpeak server and store it. Then, we have fetched this real-time data from ThingSpeak to Google Co-lab by using API key and fit Random Forest model (as Random Forest gives highest accuracy) into it. After run code, we have got our IoT final output data which shows “1” which means “medium risk factor”. As we have tested our system during sunny days, that’s why it gives “1”, which is shown in the below figure. According to our health survey we also have found that in the sunny season, the health risk factor is medium.

```
[1]
-----
KeyboardInterrupt                                Traceback (most recent call last)
```

Figure 4.14: IoT Final Output Data

Thus, we have demonstrated how to create a low-cost IoT-based environment quality monitoring method with access to the health condition of the workers. As well as being more affordable and consuming less power than regular link procedures, remote innovation additionally consumes less space, can be put for all intents and purposes anywhere, and offers more noteworthy functional adaptability.

4.3 Interface

We have used sublime text for writing the code of the web interface. A cross-stage shareware source code proofreader is called “Sublime Text”. Various markup and programming dialects are supported locally. Clients can build their abilities by adding modules, which are many times created and kept up with by the local area under free-programming licenses. We use this software with HTML, CSS, PHP, and bootstrap to make the UI/UX interface and display our entire work.

On the home page of our website, we have displayed the main interface or dashboard of the system and also graphically show a health survey and air quality index graph. In the Data Analytics part, we have shown our google-colab site by linking up. In the IoT past data, we have presented our all-past data which we have sent to ThingSpeak. In the IoT Last Data, we retrieved the IoT last data from the ThingSpeak server and we also have showed our last data with predicted results by using a table format.

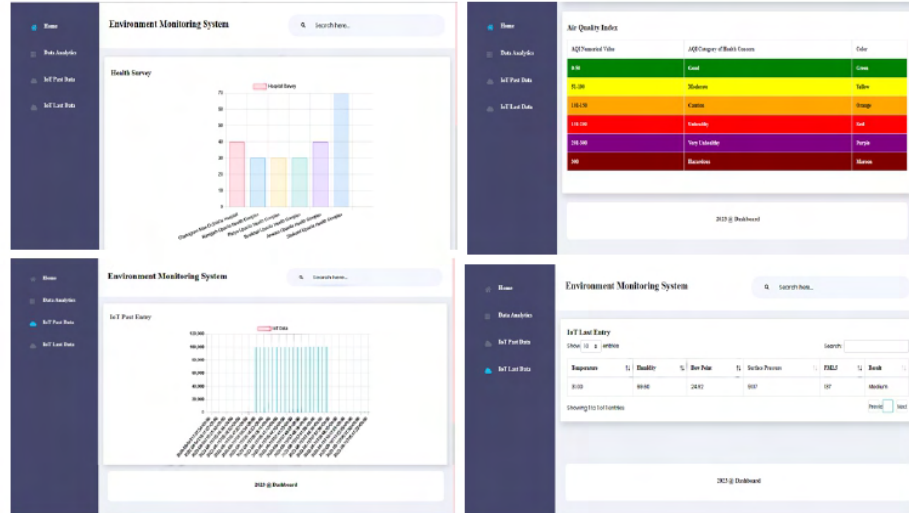


Figure 4.15: Web Interface

In figure 4.15 display the complete web interface of our system. Finally, we have cross-checked our both outcomes and found that our collected dataset with field survey gives the same result as real-time data. and have implemented our system successfully.

4.4 Discussion

We have designed an IoT-based environment monitoring system with health observation. While doing this work, we have faced so many difficulties. The industrial sensors which we have wanted for our proposed framework are not easily accessible. Besides this, the most challenging part of our system is collecting health data and collecting industrial sensors. Subsequent to considering and making a respectable attempt we could defeat the issues and effectively complete our work. For our system, we have taken randomly the past environmental data for testing purposes to check if our system is working or not. Then, we have applied different ML algorithms for finding the best accuracy. After testing several times, we have got our desired results accurately which are shown above. At last, we could successfully prepare our model and find a better outcome.

The framework that we have created has a few limitations yet the benefits of our framework are more than the disadvantages. Of the importance of national income, the shipbreaking industry cannot be stopped despite its negative effects. Instead, a sustainable strategy should be used to reduce the pessimistic reaction of shipbreaking operations in coastal zones. Bangladesh's shipbreaking industry needs to pay more attention to avoid such problems. We have tried to provide guidance for formulating a plan to reduce the environmental impact and increase health and safety protocols, which are given below:

- As the winter season is high risk in that time control the work and recover it in another season.
- An efficient format ought to be planned previously beginning to break the ship.
- An incorporated shipbreaking zone ought to be created with new materials.
- Compelling Management Plan of Environment Impact ought to be presented for the greatest contamination reduction.
- Need to create effective training facilities among workers.
- Security and health issues like hoods, safety shoes, goggles, gloves, or access to the medical care of the laborers can be ensured during the working period.
- The executives of shipbreaking tasks and government and non-government organizations can employ the review discoveries to foster a positive workspace in guaranteeing workers' health.

If these strategies will be all carryout, this would expand the seriousness of the ship-breaking industry in Bangladesh, further develop workers' health conditions, decrease harm to climate contamination, and add to building a green state.

Chapter 5

Conclusion & Future Work

Chattogram is known as Bangladesh's shipping business capital with its separated current districts and seaport. Nowadays, this business has become one of the most productive and rapidly making organizations for Bangladesh as well as everywhere. We drove a material stream assessment of steel in Bangladesh with a highlight on the shipbreaking business and already attained one of the best conditions in the national economy [49]. But unfortunately, this business has some difficulties from the point of view of socio-economic. In the assessment of various examinations, ship reusing practices and their impact on the coastline zone got very lower thought from the past experts of Bangladesh [50]. Because of the expansion of the shipbreaking industry throughout the course of recent years, Bangladesh's coastal environment has been harmed [51]. Shipbreaking yards contained high groupings of both organic and inorganic pollutants. The shipbreaking enterprises discharge critical synthetic gatherings of natural contaminations, essentially polycyclic sweet-smelling hydrocarbons, polychlorinated biphenyls, and organochlorine pesticides [52]. Oil ooze and other ship squander are spilled and blended in with the soil and water on the shore during shipbreaking, contaminating the environment. Because of lacking disinfection offices in shipbreaking yards, consistent openness to warm, dust, hurtful synthetic compounds, contaminated smoke, and so forth. These are hampering the environmental structure as well as physical and mental issues for the workers.

Our primary goal is to build a framework that can continuously monitor the environment quality with workers' health condition observation and determine that the environment of the shipbreaking industry is not safe for them. Our study area is the southeast part of Bangladesh which is one of the main businesses for our country. In this system, we have collected the past 7 years' data for analysis of environmental pollution in the shipbreaking industry area. The environmental data has been taken from some authentic sites and the health data has been taken by field surveys from various hospitals. To process these data and extract features from those data we have applied Data Analytics techniques by considering some parameters. Additionally, we have conducted a health survey (risk factor) using a time series system from different hospitals in the Chattogram region to assess the actual health condition of the ship-

breaking industry area. We have processed data and built the model by applying some ML algorithms, where all the algorithm function properly but Random Forest Classifier accuracy is higher (81.78%) than other models. We have also used the IoT technique to examine the environment quality by taking some input features in order to get real-time data. This data has been sent to the ThingSpeak server which is a free database platform with a centralized cloud system. A comparison has been given between past and current data. The overall system has been shown in a web interface. Our research finds out that the people of the shipbreaking industrial area are most affected than any non-industrial area people and the rate is too high during the winter season.

We believe that our research will be an effective one for the workers who are working in the shipbreaking industry and also it is alarming for everyone about environmental pollution. By using our Data Analytics and IoT-based real-time environmental monitoring system in the shipbreaking industrial area, hazards can be reduced and in near future, this sector may contribute more and more.

5.1 Future Work

As various climatic changes have happened during the previous 10 years, individuals living in densely populated, human-made metropolitan locales have expanded, so it is very difficult to analyze the environmental condition perfectly. Without government order, the public cannot access register books for collecting patient data from hospitals so we could not collect as much data for our survey. In the future, we will try to collect more patient data by taking government orders and trying to increase our accuracy. Our system is built for the shipbreaking industry but later we plan to deploy our system for all other industrial areas as well.

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