Climatic Data Analysis Using Machine Learning and Correlation with Human Health

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AUTHORS' PROFILE

Dr. Rohit Rastogi received his B.E. C. S. S. Univ. Meerut, 2003. Master's degree in CS of NITTTR-Chandigarh from Punjab University. He received his doctoral degree from the Dayalbagh Educational Institute in Agra, India. He is serving as Associate Professor in the CSE department of ABES Engineering College, Ghaziabad, India. He has won awards in several areas, including improved education, significant contributions, human value promotion, and long-term service. He keeps himself engaged in various competition events, activities, webinars, seminars, workshops, projects and various other educational learning forums. He has guided around 40 B. Tech. students' projects and 5 M. Tech. Thesis. He is editor and reviewer member of several international Journals and conferences. He has 100+ publications in journals and conferences of International repute. He strongly believes that Transformation starts within self.

Mr. Rayush Jain is an engineering student in the computer science department at ABES Engineering College, Ghaziabad, Uttar Pradesh, India. He is a quick learner and tries to explore things. He is in the quest to work and learn constantly and cope with the emerging latest technologies related to computer science and continue widening the spectrum of his knowledge.

Mr. Prabhinav Mishra is an engineering student in Computer Science at ABES Engineering College, Ghaziabad, Uttar Pradesh, India. He has keen interest for the technicality of the things and is currently improving his technical skills and learning more and more day by day. His hobbies are playing basketball, chess and he has a great interest in watching movies. His aim is to get better day by day and be a successful engineer in a respected firm.

Mr. Prateek Singh is an engineering student in Computer Science at ABES Engineering College, Ghaziabad, Uttar Pradesh, India. He has been keenly interested in coding and open-source projects. His hobbies are playing basketball and reading books. His wish to be a successful software engineer and to serve his knowledge to the nation.

ABSTRACT

Climatic Data Analysis & Effects on Human Health is a data science project that focuses on the analysis and interpretation of climatic data to gain valuable insights into past and present climate patterns. The project utilizes advanced data analytics techniques like regression models to process and analyze large-scale climatic datasets, enabling the identification of trends and patterns that contribute to a deeper understanding of climate dynamics.

The primary objectives of this project are to investigate climate change phenomena, assess the impact of climatic change on human health, and predict the variation of spread of diseases as per the different climatic conditions. By employing various statistical models, machine learning algorithms, and visualization tools, the project aims to uncover hidden relationships within the data and provide evidence-based findings for policymakers, researchers, and stakeholders.

To achieve these goals, the project leverages diverse sources of climatic data, including maximum and minimum temperature records, rainfall and humidity measurements, atmospheric pressure data etc. The data quality and preprocessing techniques ensure the reliability and accuracy of the analysis results. Robust data cleaning, normalization, and outlier detection methodologies are used to deal with data inconsistencies and improve the result.

Furthermore, the project's framework includes the development of predictive models that utilize historical climate data to forecast future climate scenarios. These models leverage machine learning algorithms, such as regression, time series analysis, and ensemble methods, to capture complex climate patterns and provide projections with varying degrees of uncertainty.

The outcomes of this project contribute to the broader scientific community and support evidence-based decision-making processes. The findings can help in restricting the spread of some diseases, guide urban planning strategies, assist in the development of sustainable agriculture practices, and aid in predicting natural disaster risks.

KEYWORDS

Jupyter NoteBook, Pandas, Linear Regression

MOTIVATION

Climatic change is a global issue with significant implications for human health. Understanding the relationship between climate variables and health outcomes is crucial for developing effective strategies and adapt to the changing climate. There is a wealth of climatic data available from various sources which provide a rich resource for conducting comprehensive analyses and building predictive models. Machine learning models can be trained to predict future climate conditions and their potential health impacts and can also enhance our ability to anticipate and respond to climate-related health risks. By combining climatic data with health records we can develop more comprehensive models that consider multiple factors influencing human health outcomes. It allows us to uncover hidden patterns, predict future trends, and inform policies and interventions to safeguard human health in the face of a changing climate (Yaduvanshi, A. et al., 2021)[11]; (Khan, A.A. et al., 2021) [12].

PROJECT OBJECTIVES

1. To analyze and understand the climate trends and patterns by using machine learning considering various factors associated with climate change.
2. To get an insight of the relationship between the climate changes and human health including various health issues like respiratory problems, fever, dengue etc.
3. To see the accuracy and reliability of the prediction model by analyzing the climate data and predicting it and then comparing it with the known data and hence calculate the accuracy.
4. To identify the risk factors and impact of climate change on various scales of the world including various socio economic sectors, geographical areas etc.
5. To contribute in the known knowledge of climate change and its impact on human health by giving an insight to the analysis and providing valid solutions.

SCOPE OF THE PROJECT

The scope of climatic data analysis and its effect on human health is vast. It encloses various disciplines such as climatology, public health, meteorology, sanitation, and environmental science. By analyzing historical and current climate data, trends and predicting future climate projections, researchers can identify vulnerable populations, assess risk and develop strategies to minimize the adverse health effects of climate change. It also may include setting an early warning system, improving healthcare infrastructure, implementing climate-resilient urban planning, and raising public awareness about climate-related risks to health.

Overall climatic data analysis plays a critical role in understanding the complex interaction between climate and human health, and it provides a valuable vision for healthcare professionals which predict the weather of the upcoming days and shows that at this day or the temperature these diseases can be caused on the human health.

DELIVERABLES

- Analysis of climate data and its impact on human health relies on machine learning. By inputting a large amount of data, we can predict upcoming weather patterns and identify potential health risks. To access this information, simply visit this website and follow the provided instructions. The designed software produces a research report detailing weather patterns and associated health risks.
- Gives data visualization of the climatic data and its effect on human health variables. This can include graphs, charts, maps or other visual formats to help the stakeholders to understand the patterns and trends in the data and statistical analysis. Detailed statistical analysis of the climatic data on the basis of a regression model between climate variables and human health variables.
- To provide recommendations and interventions, public awareness, policy briefs, and impact assessments on the basis of climatic data analysis and the relationship between human variables, which helps to update current policies and increase educational diversity, which indirectly helps in educational materials as well as strategies.
- Product helps you to predict the upcoming weather reports as well as give the report that today's weather can cause this type of diseases.
- Easy to access. You just have to go to this website first, then click on weather checking and give the following requirement so it can help you to forecast the weather of the day or the date that you want.
- Show the result on the basis of user preference and 24x7 accessible.

STAKEHOLDERS

The designed web application can be used by anyone such as students, elders, etc. It does not have any limitation and it is a user -friendly web-based application so, it does not require any of your user memory to operate it and any sign up to use it. It is extremely helpful for the prediction of weather forecasting of the upcoming days and it's required just some basic data to predict the outcome you desire and it's very helpful because it displays that on this day there is a high chance of this type of disease that affects the human body.

GANTT CHART

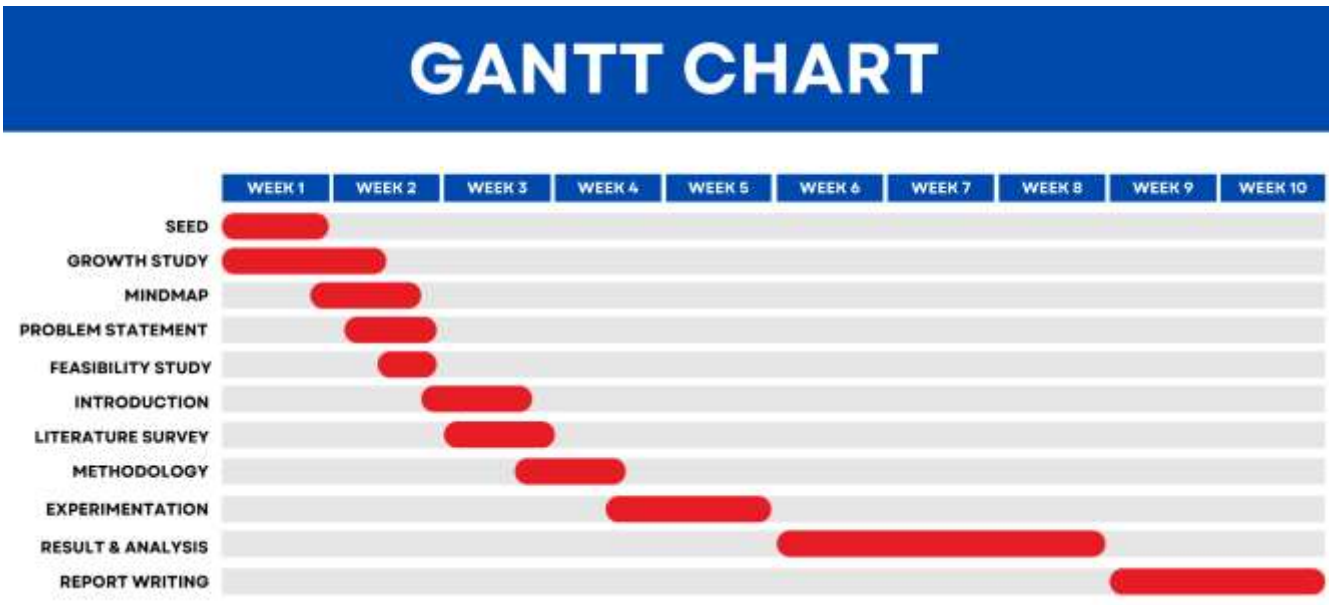


Figure 1. Gantt Chart Showing Project plan our Team

The above given Gantt Chart shows how the team managed all the work that has to be done in the given time limit of 10 weeks. The first few weeks were spent in the identification of the problem statement and then we worked on the technical and coding part of the project with report writing in continuation. In the last few weeks we analyzed the result and tested whether our results are accurate or not (as per Fig. 1).

ETHICAL COMMITTEE AND FUNDING

The experiment does include human related experiments but it is ensured that no ethical constraints should be violated. Since the research work is related to the health of humans, thus their data has been collected by the author's team but it is ensured that the study doesn't violate any ethical laws. The research work only works upon the data collected through the survey; rather there was not any experiment which is directly performed on human beings. The Project is not funded by any agency.

1. INTRODUCTION

Understanding and reducing the effects of climate change depend heavily on the prediction of climatic data. Making educated decisions in a variety of industries, including agriculture, infrastructure planning, and disaster management, is made possible by accurate climate pattern predictions. The relevance of data analysis, modeling, and cutting-edge technologies is emphasized in this study paper's examination of the strategies and approaches employed in predicting climate data. This study intends to increase our capacity to predict future climate trends and create successful adaptation and resilience strategies by addressing the difficulties and developments in climate data prediction.

1.1 Background and Importance of Climate Data Prediction

Climate data prediction plays a very vital role in facing the challenges and hardships thrown at us by climate change. Basically climate data prediction involves the collection of vast amounts of climatic data and then we analyze it by using different algorithms then we interpret it to forecast the future patterns and trends of climate. As we can see nowadays that climate is very unpredictable, the rising temperatures, heatwaves, floods, storms etc. all these events indicate that prediction of climate is very essential for the positive impact on human health. By analyzing the past or historical data of climate change and using advanced modeling techniques and research to get an insight of relationships between climate change and health outcomes. Timed and accurate data will help in increasing the accuracy of our research and also help us in understanding the correlation between climate change and health challenges imposed through it (Dhamodharavadhani, S. et al, 2016)[4]; (Vázquez-Ramírez, S. et al., 2023) [13].

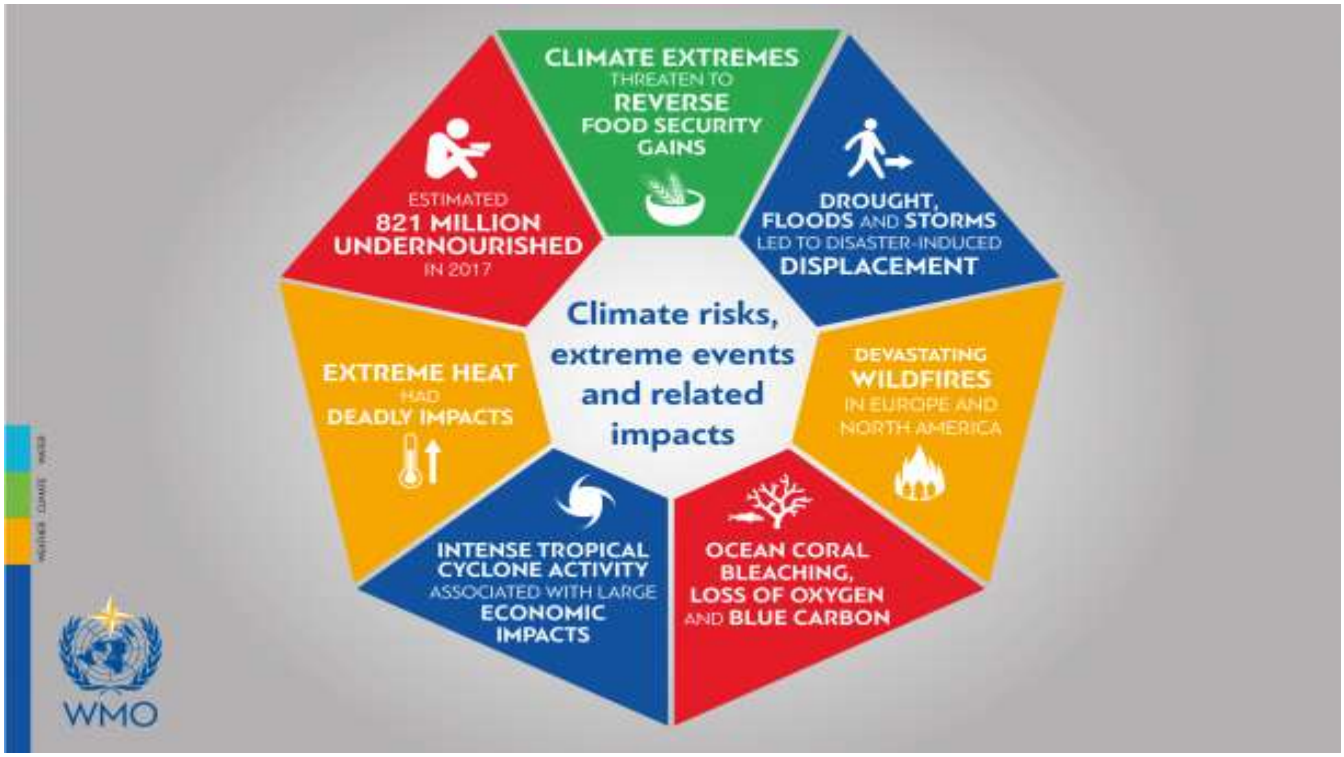


Figure 2. Various impacts and harm caused by climate change
Source: https://public.wmo.int/en/media/news/climate-change-impacts-highlight-need-action-cop24

The above image consists of various calamities caused by the impact of climate change. As we can see in the image climate change causes undernourishment of people, it also degrades the chances of food grains, floods, drought and storms that are harming resources, forest fires, ocean coral bleaching, extreme rise in temperatures and heat waves which shows a direct impact on human health (as per Fig.2).

1.2 Use Of AI And Ml To Analyze Climate Change For Sustainable Development

The use of Artificial Intelligence (AI) and Machine Learning (ML) has become increasingly important in analyzing climate change. These models help scientists understand past climate patterns, make projections for the future, and assess the impact of various factors on climate changes. By analyzing historical weather patterns, these algorithms can identify early warning signs and provide accurate forecasts, enabling governments and communities to take proactive measures to minimize the damage caused by such events (Vishwakarma, H. et al, 2018)[10].

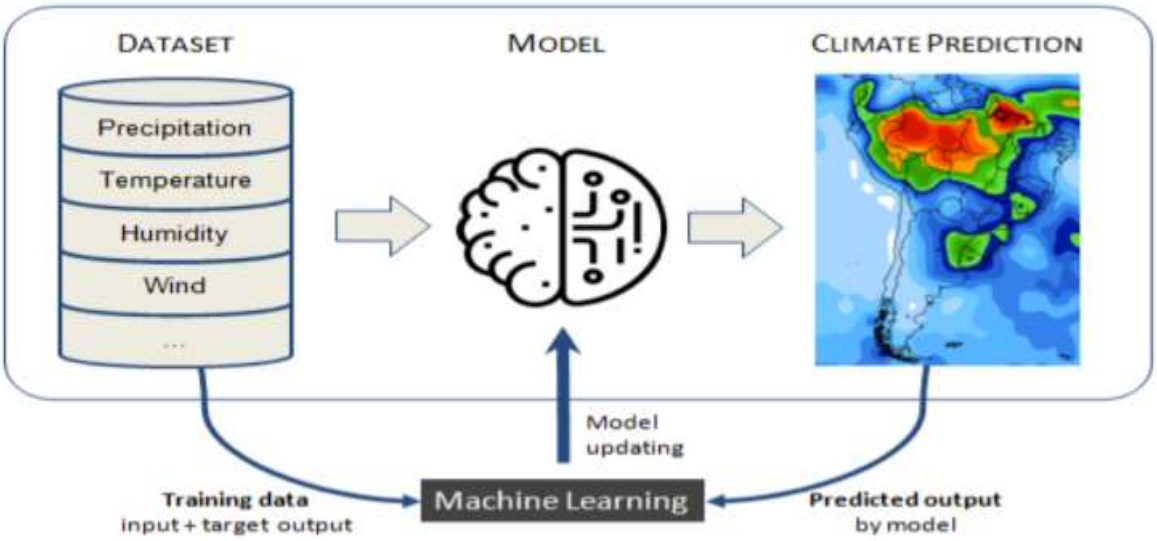


Figure 3. ML Model for Climate Change Prediction

Source: https://medium.com/@sej.uoft/machine-learning-applications-in-climate-prediction-analytics-60456d6c6a85

AI and ML play a crucial role in analyzing climate change and promoting sustainable development by enhancing climate modeling, predicting extreme weather events, assessing climate risks, optimizing energy consumption, facilitating carbon sequestration, improving agricultural practices, and monitoring environmental changes. By harnessing the power of these technologies, we can make more informed decisions to address climate change and work towards a sustainable future (as per Fig. 3) (S. Adivarekar, et al., 2023)[14].

1.3 Climatic Change in 21st Century Society

Global temperatures have been steadily increasing due to human activities, primarily the burning of fossil fuels and deforestation. This has resulted in significant consequences such as heatwaves, changes in precipitation patterns, and the melting of ice caps and glaciers. These changes in climate have also led to alterations in weather patterns, resulting in more frequent and severe extreme weather events like hurricanes, droughts, floods, and wildfires. These events can have devastating impacts on ecosystems, infrastructure, and human lives.

One of the most visible effects of climate change is the rising sea levels caused by the melting of polar ice caps and glaciers. This poses a significant risk to coastal communities, leading to increased flooding, coastal erosion, and the salinization of freshwater sources. Small island nations are particularly vulnerable to the effects of sea-level rise (Balasubramanian, M., 2012)[1]; (Nwokolo, S.C.; et al., 2023) [15].

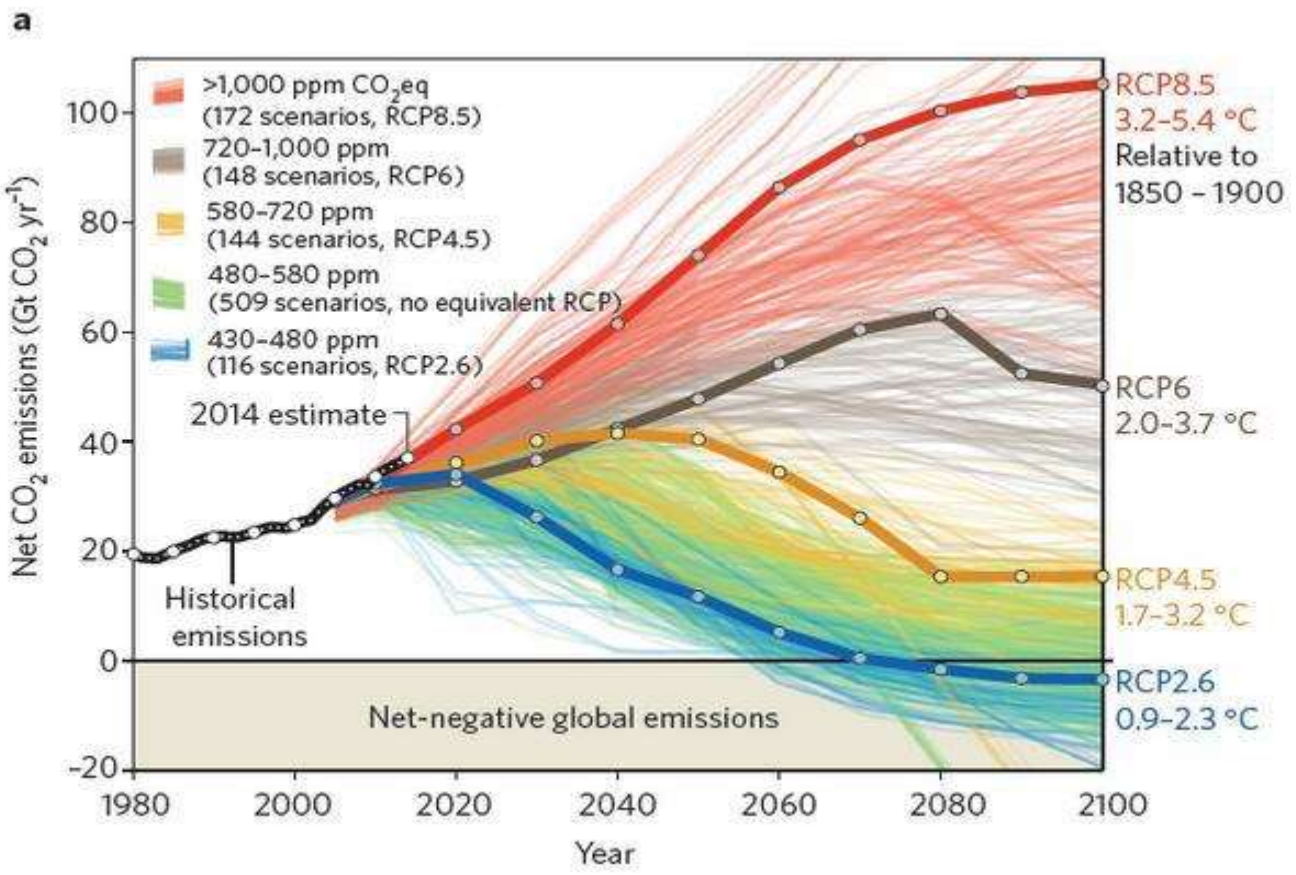


Figure 4. Global emission of CO2

Source: https://www.earth.com/earthpedia-articles/climate-change-in-the-21st-century/

To address these challenges, it is essential for 21st-century society to prioritize climate action. This includes reducing greenhouse gas emissions, promoting sustainable practices, and investing in resilient infrastructure and systems. Collaboration among governments, businesses, communities, and individuals is crucial to effectively address the challenges posed by climate change and ensure a sustainable future for generations to come. It is vital to work together to mitigate the causes of climate change and adapt to its impacts to create a healthier and more sustainable planet for all (as per Fig. 4).

1.4 Climate Change Impact on Health

Rising temperatures can result in increased heat waves, which can lead to heat-related illnesses such as heat exhaustion and heatstroke. Vulnerable populations, including the elderly, children, and individuals with pre-existing medical conditions, are particularly at risk. Warmer temperatures can also exacerbate the spread of infectious diseases, such as vector-borne diseases like malaria and dengue fever, by expanding the range of disease-carrying vectors.

Climate change can impact air quality through various mechanisms. For example, higher temperatures and stagnant air can increase the formation of ground-level ozone, which is harmful to human health. Changes in precipitation patterns can impact water quality and availability. Floods and heavy rainfall events can contaminate water sources, leading to outbreaks of waterborne diseases such as cholera and dysentery. Climate change can also affect agricultural productivity, food security, and food safety, with implications for nutrition and the spread of foodborne illnesses (Balasubramanian, M., 2012) [1]; Eisenstadt, T.A.; et al., 2023) [16].

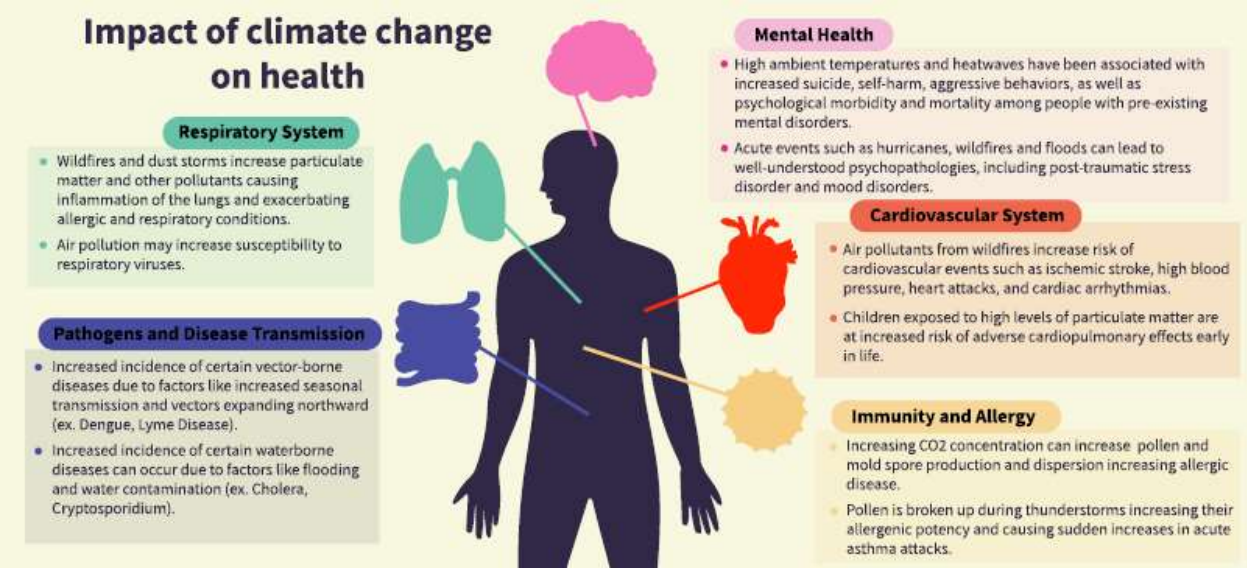


Figure 5. Impacts of climate change on health
Source:https://www.orfonline.org/expert-speak/climate-and-human-health/

To address these challenges, it is important to mitigate climate change by reducing greenhouse gas emissions, transitioning to renewable energy sources, and adopting sustainable practices(as per Fig. 5).

1.5 Climate Change Impact on Global Crop Production

The impact of climate change on agriculture can result in lower crop yields, heat waves and flooding are also increasing the pest and plant diseases and the drought is also caused by nutrition quality. The climate change impact is making difficult to perform agriculture activities which directly reduce the human needs. Asia, is the most populated subcontinent that has a population around of 4.5 billion people and making it 60% of the world total population for meeting food demands and ensuring food policies in Asia is challenging due to the over rated population growth and which directly caused an increased vulnerability to climate change. In Asia despite low greenhouse gas emissions, India and China are major contributors of carbon dioxide emissions.

There are many direct impacts from changing weather. Rising Temperature is also directly caused due to sudden changes in temperature and weather patterns which affect farming. Heat Waves are directly linked to climate change and largely reduce the yield in many parts of the world. Heat Stress of livestock caused due to the animal growth and reproduction as well as their feed intake cycles. Changes in rainfall also can cause both floods and droughts in the crop yields. Indirect impact of climate change is Pest insects have pathogens that take 10-16% of the global harvest and this rise as plants are at an ever-increasing risk. Warmer temperatures can increase the insect population to a large number. Climate change also contributes due to drought locust swarms, as CO2 levels make soybean, fall armyworms, etc. And other indirect impacts are food security, food prices, agriculture land loss from sea levels rise and many more.

Basically speaking there are several conditions or effects that directly as well as indirectly impact on the rising of Global crop production as well as falling crop. So, the rising and falling of crop production causes many changes such as sudden increment in price, food insecurity, etc(Habib-ur-Rahman M. et al, 2022)[6]; von Gehren, P.; et al., 2023)[17].

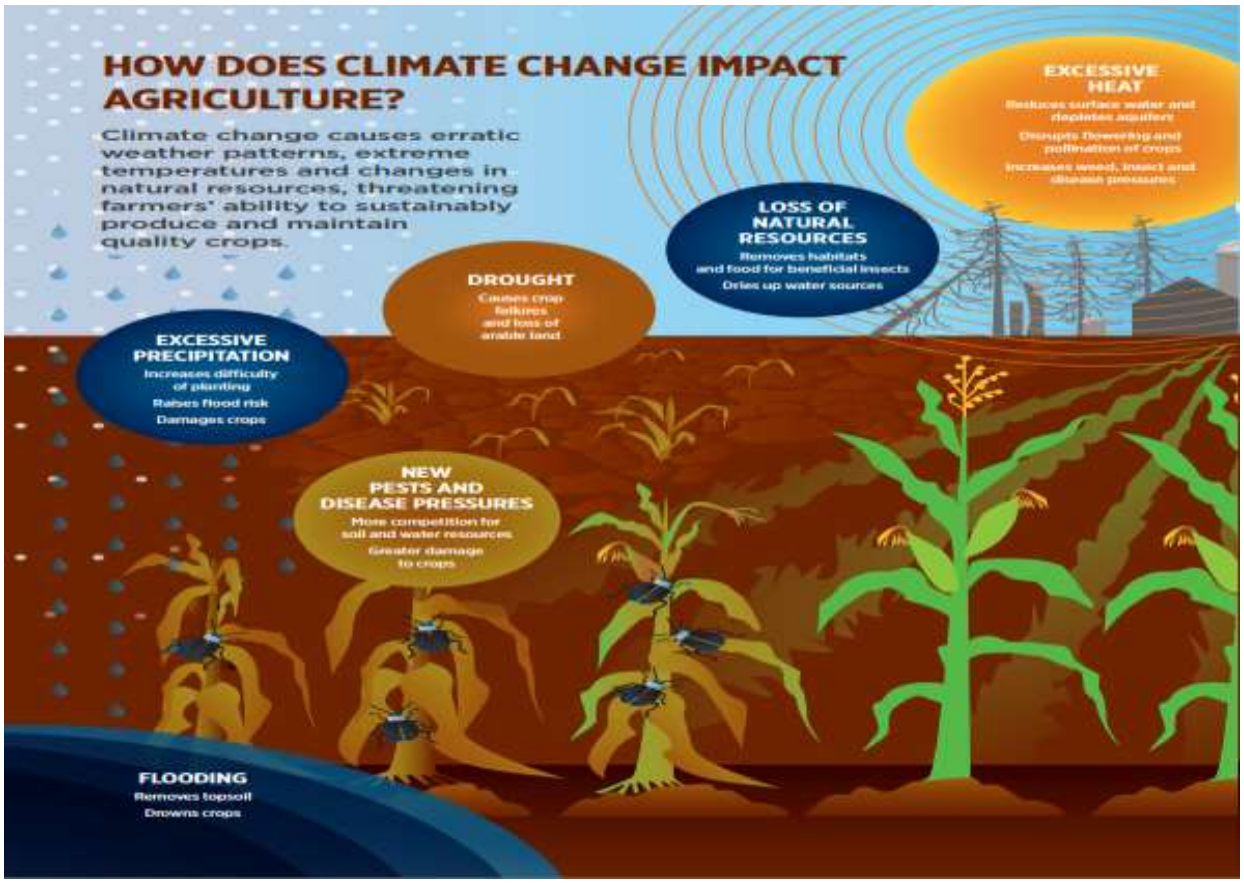


Figure 6. Impacts of climate change on Global crop production

Source:https://www.theindianwire.com/environment/can-agriculture-in-india-play-a-key-role-in-limiting-climate-change-a-study-defines-how-323660/

The above image consists of various factors that are caused by climate change. As we know, climate change causes excessive heat, loss of natural resources, drought, excessive precipitation, new pests and disease pressures which show the impact caused by climate change on crop production(as per Fig. 6).

2. LITERATURE REVIEWS

The literature survey done for this research paper "title" explored a vast knowledge of various existing articles, research papers, and scientific publications. The literature survey aims to examine the existing knowledge of climate data prediction and its effects on human health. Through this literature survey we build up a better understanding of the relation between climate changes and human health providing a solid foundation for the analysis work.

Hemalatha, G. et al. (2021) and his team demonstrated a weather prediction model using advanced machine learning techniques. The team was motivated by the dynamics of the weather and research that promotes an efficient prediction model. The team came to a point that nowadays linear models are used for prediction which do not consider the non-linearity of the input data. Non-linear models are more preferred for the research in recent years. The weather prediction models are classified as 1.Data classification 2.Data clustering 3.Data prediction. In data classification the prediction of weather is done using the input parameters. In data clustering the input data is clustered and then the prediction model is runned. In data prediction the prediction is done using linear or non-linear data.

According to the present study the current weather prediction models do not consider the non-linear relationship of input parameters and output parameters. Seeking motivation from these factors a fully connected neural network model (FCNN) is provided for the weather data classification. The FCNN model also supports the non-linearity between the input parameters and the output parameters.

A FCNN model is recommended in the current study for the prediction of weather data. The suggested FCNN model has the capacity to train and generalize, capturing the nonlinear properties of the input features in the dataset. In terms of OA, UA, PA, and KC, the model fared better than other models of a similar type. With the IMD dataset as a test, the model generated an OA of 87.83%. Additionally, the model may be expanded to classify higher dimensional datasets(Hemalatha, G. et al. 2021)[7].

Biswas, M. et al. (2018) and her team demonstrated a Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data. The team sought the problem of changing weather conditions which is the most difficult issue the world over. Weather forecasting is a method that is used to predict the weather of a given area. The team wrote this paper and used a classifier approach for weather prediction and also uses naive baye's algorithm and chi square algorithm. Weather forecasting is of a different league to all the experimentally and technologically issues that are addressed over the world.

The team served a web application with a graphical user interface. The user will login in the web application with designated user id and password. The user has to enter some information like current outlook, temperature, humidity, wind condition etc. The web application will analyze the following parameters and fetch the result from the database, two basic functions namely specific classification (training) and prediction (testing) will be performed.

This paper's working model works with a mix of naive bayes and chi square algorithm for the prediction of weather. The constant time series data is assembled and analysis is performed using the interface of the Weather Prediction System developed using Java, eclipse tool. This framework predicts the risk of weather prediction according to the input and this methodology also considers the non-linear relationship to predict better output. Future work of the project is to handle more attributes related to the weather and predict accurate and better responses (Biswas, M. et al. 2018) [2]; (Gemeda, D.O.; et al., 2023) [18].

Holmstrom, M. et al. (2016) and his team demonstrated that traditional weather forecasting models based on physical principles have limitations and can be inaccurate over longer periods. The study aimed to enhance weather predictions by employing machine learning techniques, specifically focusing on forecasting temperatures for a week using data from the previous two days.

Two models were utilized: linear regression and a modified version of functional regression that captures weather trends. However, both models did not perform as well as professional weather forecasting services. Nevertheless, as the forecast period extended, the difference between the team's models and the professional ones decreased. This suggests that their models have the potential to improve their accuracy over longer time frames.

When comparing the models, the linear regression model was found to be more effective than the functional regression model. This suggests that if the forecast period is extended to four or five days, the functional regression model could potentially outperform the linear regression model by capturing relevant weather patterns.

In conclusion, the research highlights the limitations of traditional models for long-term weather forecasting and explores the potential of machine learning techniques. Although their models were not as accurate as professional services, they show promise for excelling over longer time scales. Additionally, extending the forecast period for functional regression could enhance its performance compared to linear regression by capturing more significant weather trends(Holmstrom, M. et al. 2016)[8].

Bush, F. et al. (2011) and his team demonstrated that the problem in India is huge due to climate change and its potential to worsen diseases like malaria, dengue, yellow fever, cholera, and chikungunya. This is particularly concerning for people already facing poor sanitation, pollution, malnutrition, and lack of drinking water. There is a lack of adequate research on these risks. They suggested improving the collection and analysis of weather, environment, location, and health data, while simultaneously implementing strategies to adapt to these challenges (Camuffo, D.; et al., 2023)[19].

In 2009 the Joint Indo-U.S. Workshop on Climate Change and Health was conducted in Goa that aimed to discuss the current state of the science and outline future research directions related to the human health effects of climate change in India. The workshop recognized that many of the predicted effects of climate change are likely to become a reality in India, which is a diverse country with a large population and undergoing rapid urbanization. Climate change poses a significant stressor that will magnify existing health threats in India. The workshop emphasized the need to understand the relationship between climate variability and human health in India to develop new prevention strategies and early warning systems, with implications for the developing world.

Several key areas of research were Poverty and Baseline Vulnerability, Waterborne Infectious Disease, Heat Stress and Air Pollution, Vector-Borne Disease. The workshop highlighted the urgent need for research, collaboration, and interventions to address the health impacts of climate change in India. By understanding the relationship between climate variability and health outcomes, India can develop targeted prevention strategies, enhance public health infrastructure, and help vulnerable communities better cope with climate change.

They concluded that there is a lot of variation in how climate change affects human health, and this is influenced by factors like study design, location, and socioeconomic differences. We need more comprehensive studies specific to India's climate and population to understand the impact of climate change on health in the country(Bush, F. et al. 2011)[3].

Patel, A. et al. (2021) and his team demonstrated a weather prediction using Machine Learning by combining historic weather information from nearby cities with information from an individual location. This data is used by machine learning models that can accurately forecast weather of the upcoming days. This model is affordable and requires less resources than the computing system but still provides fast and reliable forecasts that can be used in our daily lives. The methodology are Spyder IDE, GNU Octave, Jupyter Notebook and Python libraries that is used to collect previous weather data that includes variety of crucial factors such as that influence the weather change set. It is typically divided into various sections that are valuable to the machine in the learning model and those parts that aren't and then appealing with data preprocessing. So, the cleaned dataset divides into two parts: the training set and test set. The training set is used to compute the result of a machine learning model, while the testing set is used to find out the results, compare the real and measured values, and use a benchmark as an error value. Now it visualizes the relations graph of data set

The most crucial details in the text are that features of scaling are an essential aspect of ML models, and outliers should be avoided or neglected before determining the best match. Professional weather forecasters are usually more dependable than this linear regression model's predictions, as weather is a nonlinear system. Additionally, unlike most forecasters, I based all of my predictions (Sondermann, M. et al., 2023) [20].

The quadratic hypothesis cannot be used in the ML model due to its tendency to falling, so the hypothesis function should be cubic and the scaling is most crucial since its value increase as the degree of the polynomials and the conclusion of this paper is to introduce a technology that uses machine learning methods to produce weather forecasts. It consumes less resources and can be run on almost any machine, including mobile devices. In the future, we plan to collect weather data from various parts of a city using minimum cost internet of IOT devices and our model predicts even further data if we combine it with data from various weather stations (Patel, A. et al., 2021)[9]; (Khandare, A. et al., 2023)[21].

Dhillon, A. et al. (2019) and his team developed a Machine Learning in Healthcare Data Analysis: A survey that analyzes various healthcare data. Health care is a system that includes improving medical facilities to serve the medical demands of the people. In India, healthcare analysis is handling various types of disease such as diabetes, skin diseases, cancer and so using machine learning. As we know cancer is the one of the deadliest diseases with around 12% cause of lung cancer and 10% deaths from it. To handle such diseases, we need to create a healthcare analysis Machine Learning (ML) system that provides correct and accurate quality of data and Machine Learning (ML) has been suggested in health care services for better understanding of data and decision-making process. There is various types of Machine Learning algorithms used in it are supervised, unsupervised, reinforcement and semi-supervised (S. Shitarth et al., 2023) [22].

Results are divided based on several types of healthcare data, such as clinical data, sensor data, transcriptomic data, genomic data, proteomic data and omics data that calculated out various types of conditions in it like temperature, humidity, etc. that directly affect the health base diseases and finally, after processing combining various data forms it predicts the health survey of the person. Machine Learning algorithms are used to analyze various types of healthcare data, such as clinical, omics and sensor data. A survey found that various machine learning algorithms and features extraction techniques are suggested by authors for the survival prediction of cancer patients (Dhillon, A. et al., 2019)[5]; (Chopra, M. et al., 2023)[23].

The tabular summary provides the gist of all papers reviewed (Refer Table 1).

Table 1. Summary of Reviewed Papers

Paper Title & Author	Introduction	Methodology	Future Scope	Result	Conclusion
Weather Prediction Model using Advanced Machine Learning Techniques (Hemalatha, G. et al. 2021) [7].	The team was motivated by weather dynamics and made a weather prediction model.	Fully Connected Neural Network Model (FCNN).	The model may be expanded to classify higher dimensional datasets.	With the IMD dataset as a test, the model generated an OA of 87.83%.	The suggested FCNN model has the capacity to train and generalize, capturing the nonlinear properties of the input features in the dataset.
Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data (Biswas, M. et al. 2018) [2].	The team made a web application that can predict weather.	Regression Machine Learning, Naive bayes, Chi square, Java, Eclipse tool.	Handle more attributes related to weather.	The web app predicts the weather of future	The web application predicts the future weather by the given ample information
Machine Learning Applied to Weather Forecasting (Holmstrom, M. et al. 2016) [8].	It is a machine learning based project in which the main focus is to generate more accurate results over a long period.	Two algorithms were used for data analysis. Linear regression and functional regression.	The models can be improved by collecting more data and adding more days.	Over longer time periods, this model has the potential to surpass the accuracy of professional forecasts.	The research highlights the limitations of traditional models for long-term weather forecasting and explores the potential of machine learning techniques.
Impacts of climate change on public health in India: future research directions (Bush, F. et al. 2011) [3].	The problem in India is huge due to climate change and there is a lack of adequate research on these risks.	Research based on the Joint Indo-U.S. Workshop on Climate Change and Health in 2009.	More comprehensive studies specific to India's climate and population needs to be done.	The workshop highlighted the urgent need for research, collaboration, and interventions to address the health impacts of climate change in India.	They concluded that there is a lot of variation in how climate change affects human health, and this is influenced by several factors.
Weather Prediction Using Machine Learning (Patel, A. et al. 2021) [9].	The team made a weather prediction machine that collects the historical weather data from nearby cities and individual cities	They used machine learning algorithms in two categories: Supervised Learning and Unsupervised Learning.	They want to reduce the variance to get a better prediction as well as resulting in a successful ML model. And I want to predict	The hypothesis function is used in showing the feature scaling in critical degrees of cubic or higher.	It is a weather forecasting machine which consumes less resources and applicable for almost any machine, including mobile devices also.

	and predicts the upcoming weather.		the data from a single location rather than various locations.		
Machine Learning in Healthcare Data Analysis: A Survey (Dhillon, A. et al. 2019) [5].	The team made a healthcare data analysis machine learning program which helps to find out the various types of disease.	They used machine learning algorithms, such as supervised, unsupervised, semi-supervised and reinforcement which were used in data forms.	Try to reduce the cost and consumption of resource that are required to perform the prediction of data so it can affordable to everyone,	To predict diseases on the basis of various forms of data.	It is very helpful in the medical facilities to improve the medical demands for the people.

3. METHODOLOGY

The whole work can be understood by certain UML diagrams shown below.

3.1 Use Case Diagram

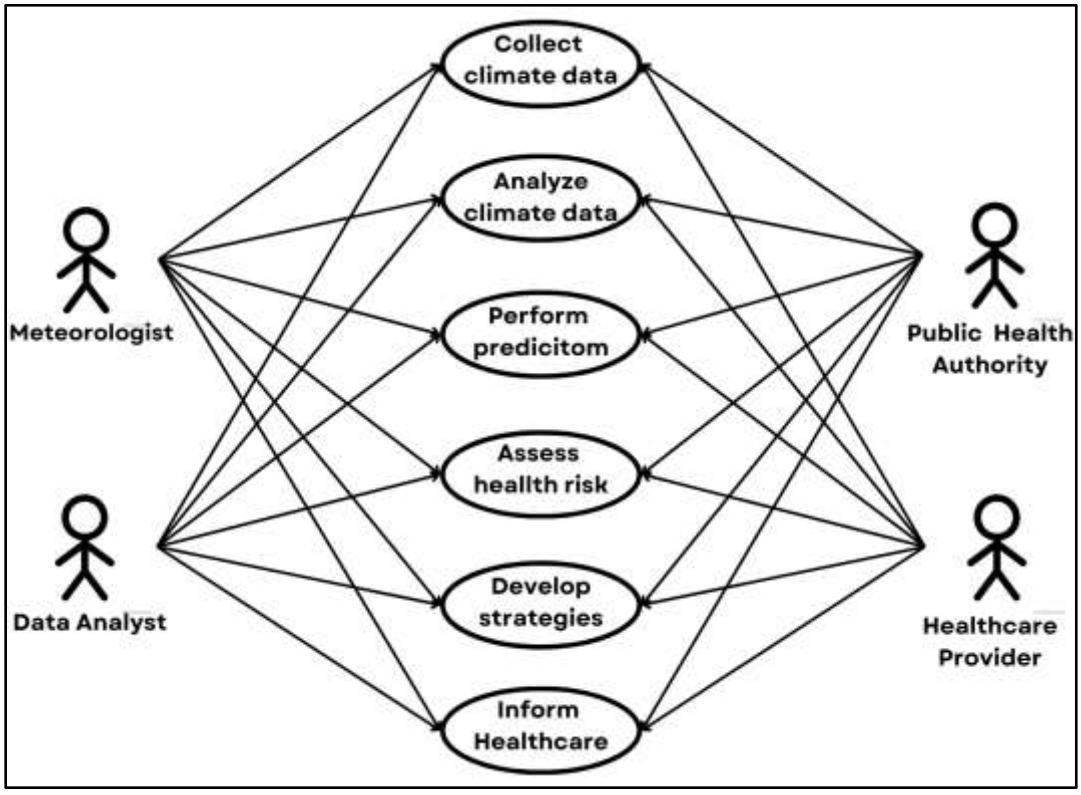


Figure 7. Use Diagram of Climate prediction and its effect on human health

The above shown image tells us how various users can use the vast amount of use cases provided by our model. Namely meteorologists can use the data and can get help in predicting the climate, data analysts can use the data for their analysis work, Public health providers can use the data for ensuring the wellness of the citizens and lastly the healthcare providers can also use the data for betterment of their facilities (as per Fig.7).

3.2 ER Diagram

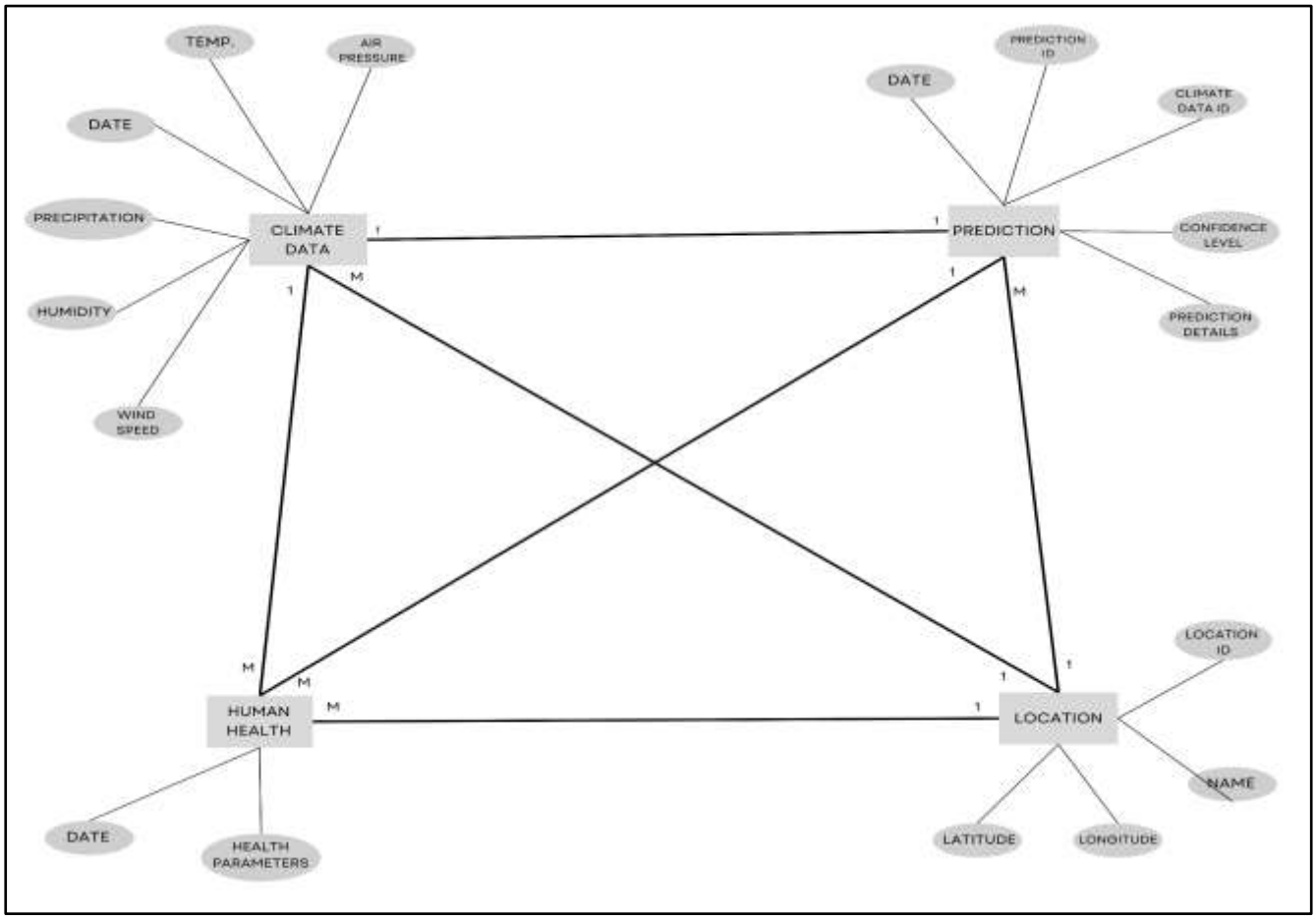


Figure 8. Entity Relationship Diagram Showing Entities and Their Relationships

The above shown diagram is an entity relationship diagram that shows various entities used in the project and the relationship it holds with other entities. As shown, climate, prediction, human health and location are the entities and various other factors such as date, time, pressure, id, latitude are the corresponding relationships. The entities are also correlated. Human health is related to climate data, prediction and location similarly every other entity is related to other entities in one to one or many to one fashion (as per Fig. 8).

3.3 Data Flow Diagram

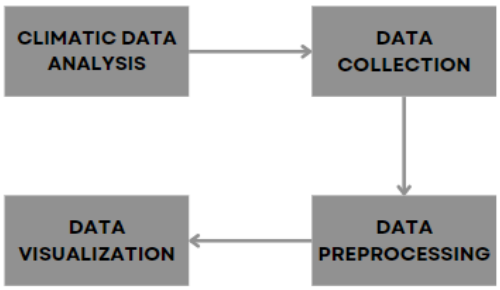


Figure 9. Block Diagram of Climate Prediction

The above diagram is a data flow diagram which shows the flow of data of our project. Firstly we analyzed the climate data, what type of data is present on the net. After that we started to collect the required dataset, then we processed the data using our algorithm and then we visualized the data by plotting graphs (as per Fig. 9).

3.4 Flowchart

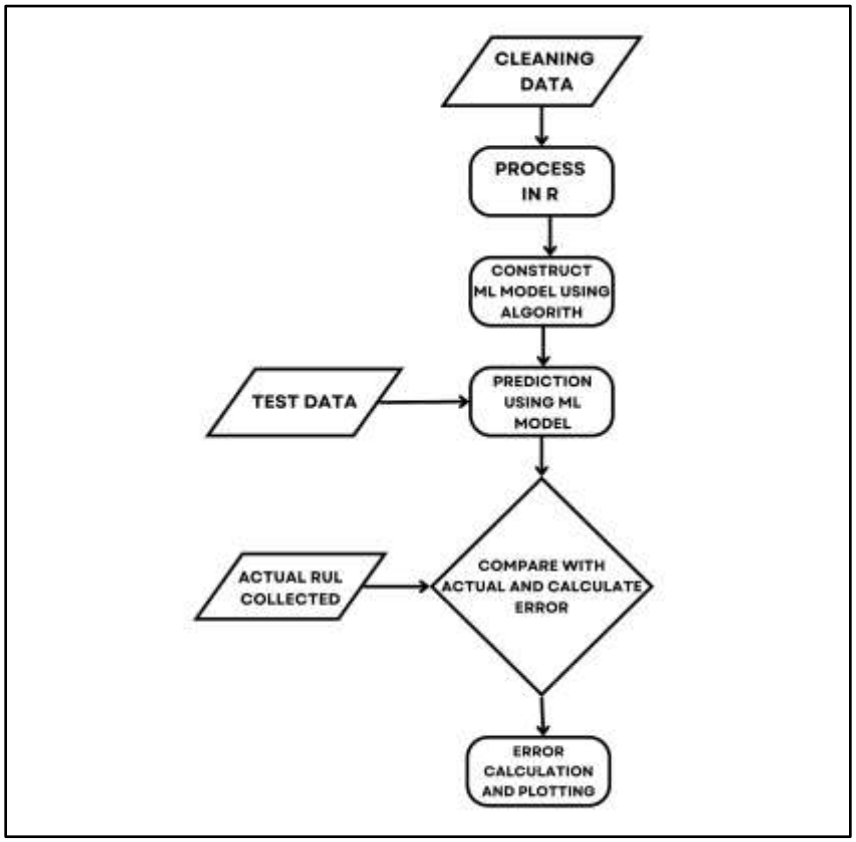
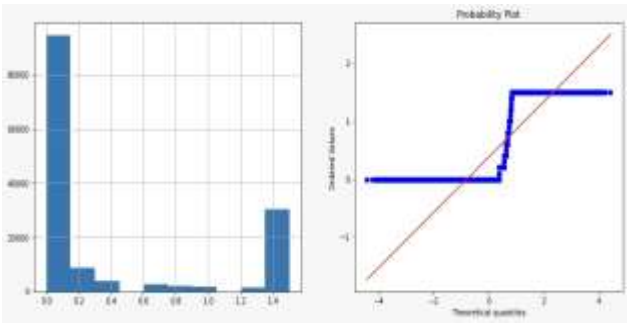


Figure 10. Flowchart Showing the Flow of the Analysis

The above shown image consist of a flowchart of the data analysis model which starts from cleaning the dataset first then preprocessing of the dataset in R then constructing a machine learning model using algorithm, then we perform prediction using the model with a test data and then we use the actual collected data and then we compare the predicted data and the actual one and calculate the errors and accuracy and then we plot the graphs (as per Fig. 10).

4. RESULTS AND DISCUSSIONS

4.1 Rainfall



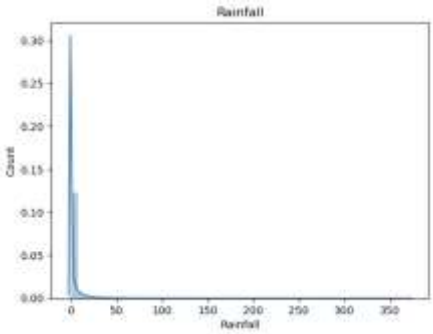


Figure 11. Rainfall distribution plots across India

Table 2: Rainfall Statistics

Mean	0.381674
Minimum	0
Maximum	1.5
Zeros	94341
Zeros (%)	64.9%

The above figure shows the distribution of rainfall in India. It is observed that most of the data fields have value 0 which shows that most of the cities have several days of no rainfall. The maximum rainfall observed on a particular day is 1.5. The mean rainfall is around 0.38. It can be concluded that most of the cities have average rainfall (Refer Table 2).

4.2 Minimum Temperature

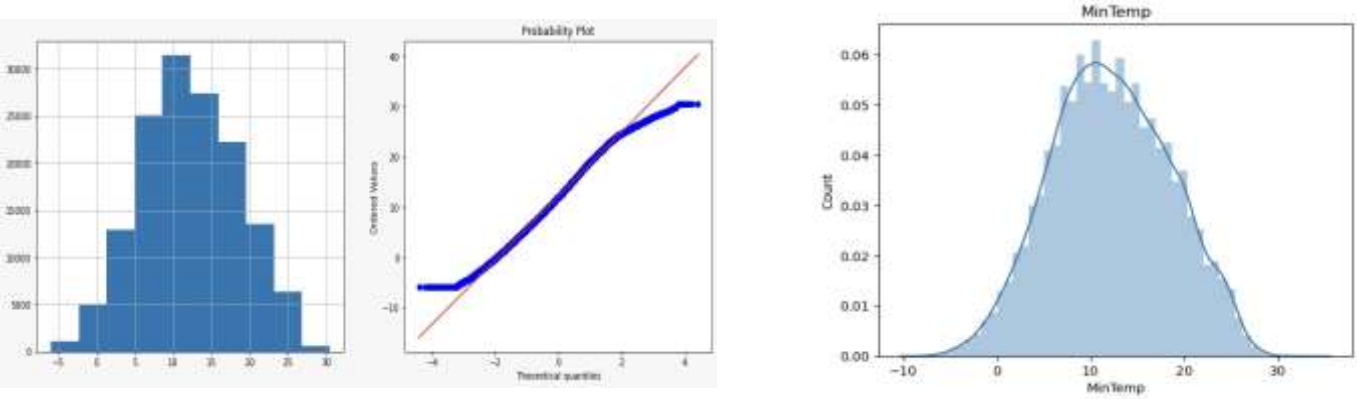


Figure 12. Minimum Temperature analysis (Refer Table 3)

Table 3: Minimum Temperature Statistics

Quantile Statistics		**Descriptive Statistics**	
Standard deviation	6.3644988	Minimum	-5.95
Coefficient of variation (CV)	0.52200815	5-th percentile	1.8
Kurtosis	-0.46306507	Q1	7.7
Mean	12.192336	Median	12

Median Absolute Deviation (MAD)	4.5	Q3	16.8
Skewness	0.023254679	95-th percentile	23
Sum	1773497.2	Maximum	30.45
Variance	40.506845	Range	36.4
Monotonicity	Not monotonic	Interquartile range (IQR)	9.1

4.3 Maximum Temperature

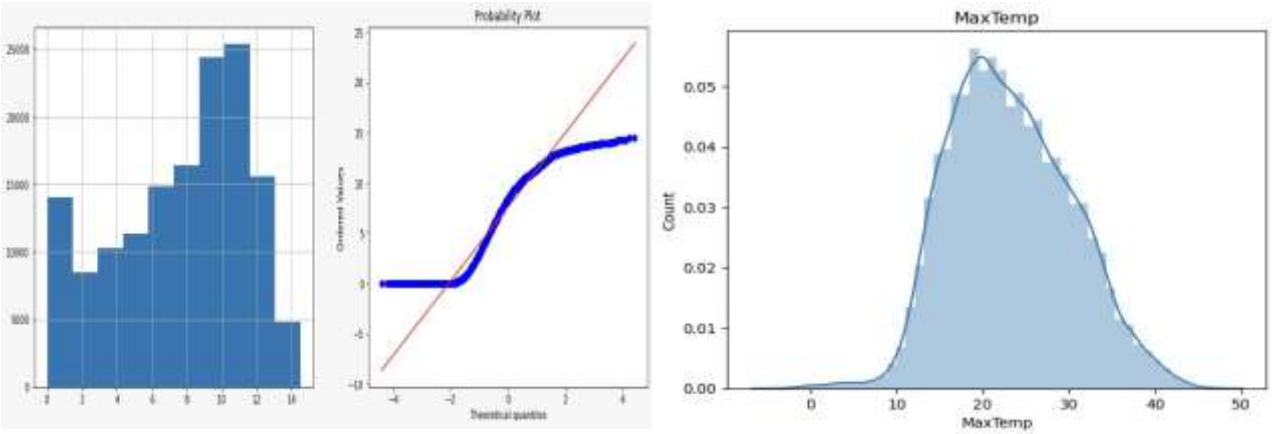


Figure 13. Maximum Temperature analysis (Refer Table 4)

Table 4: Maximum Temperature Statistics

Quantile Statistics		Descriptive Statistics	
Standard deviation	7.0678039	Minimum	2.7
Coefficient of variation (CV)	0.30438749	5-th percentile	12.9
Kurtosis	-0.28126399	Q1	18
Mean	23.219758	median	22.6
Median Absolute Deviation (MAD)	5	Q3	28.2
Skewness	0.24072645	95-th percentile	35.4
Sum	3377546	Maximum	43.5

Variance	49.953852	Range	40.8
Monotonicity	Not monotonic	Interquartile range (IQR)	10.2

4.4 Sunshine

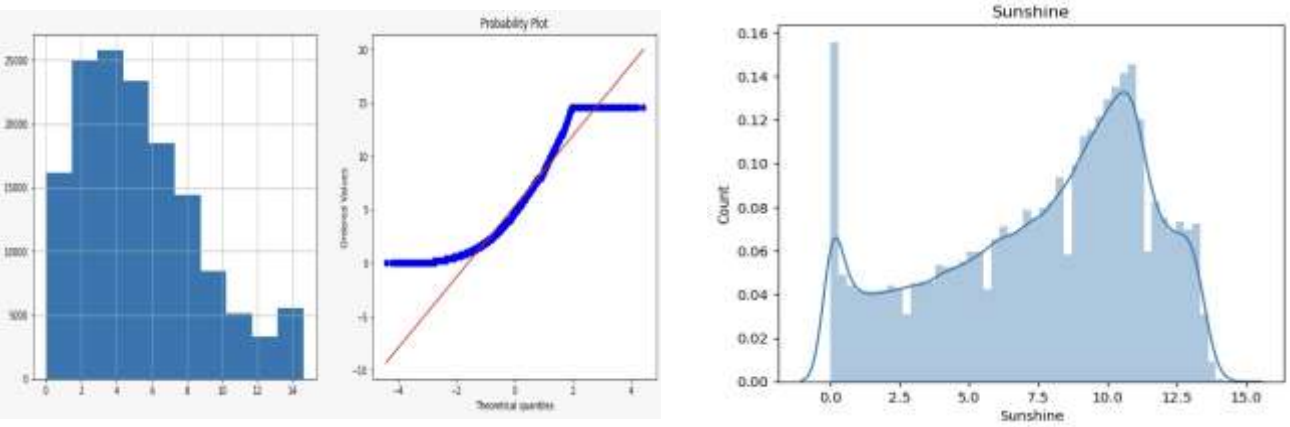


Figure 14. Sunshine analysis (Refer Table 5)

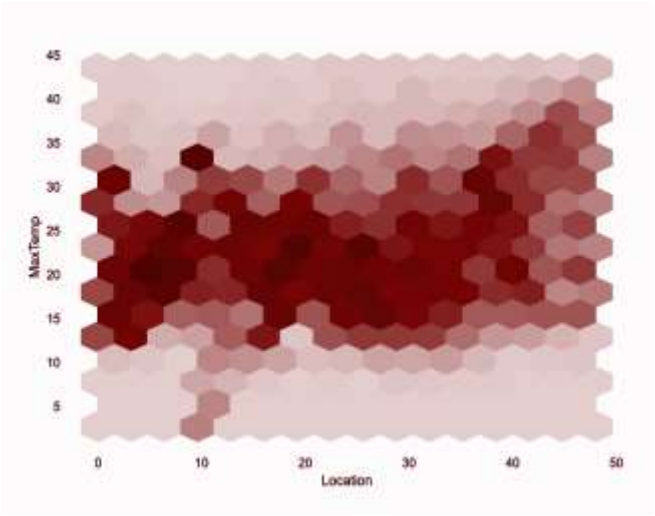
Table 5: Sunshine Statistics

Quantile Statistics		**Descriptive Statistics**	
Standard deviation	3.7859826	Minimum	0
Coefficient of variation (CV)	0.49752446	5-th percentile	0.3
Kurtosis	-0.83195988	Q1	4.8
Mean	7.609641 1	median	8.4
Median Absolute Deviation (MAD)	2.6	Q3	10.6
Skewness	-0.49465051	95-th percentile	12.8
Sum	1106898.4	Maximum	14.5
Variance	14.333664	Range	14.5
Monotonicity	Not monotonic	Interquartile range (IQR)	5.8

4.5 Other Interactions

The complete analysis of each and every parameter is done. There are two sections in the given figure below in which all the variables are present. We can select one variable from each section and the Hexbin plot of those two variables is made. This

analysis helped in understanding the relation between different variables.



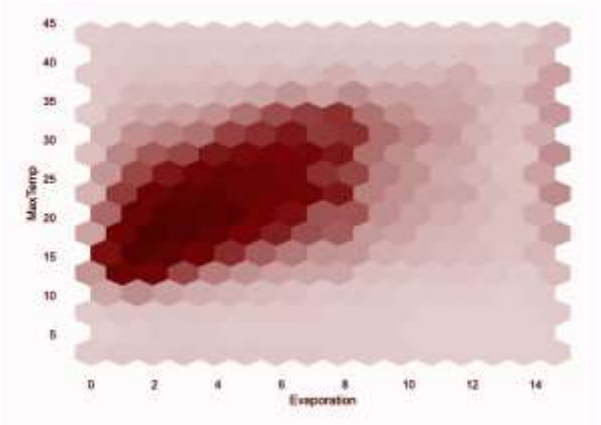
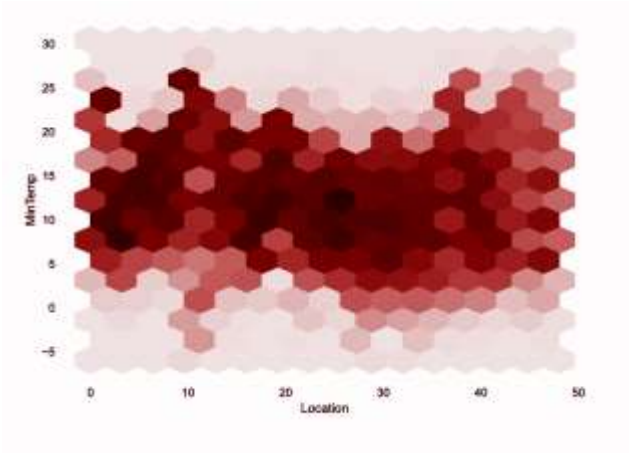
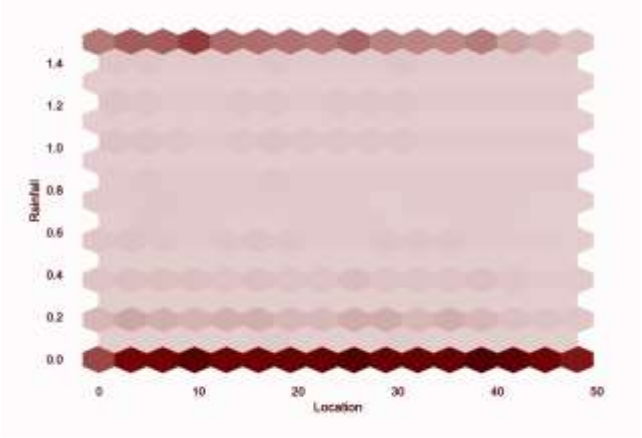
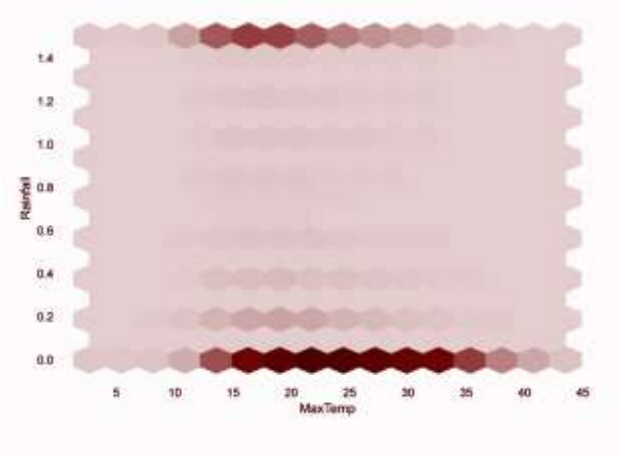


Figure 15. Interaction between different variables of dataset







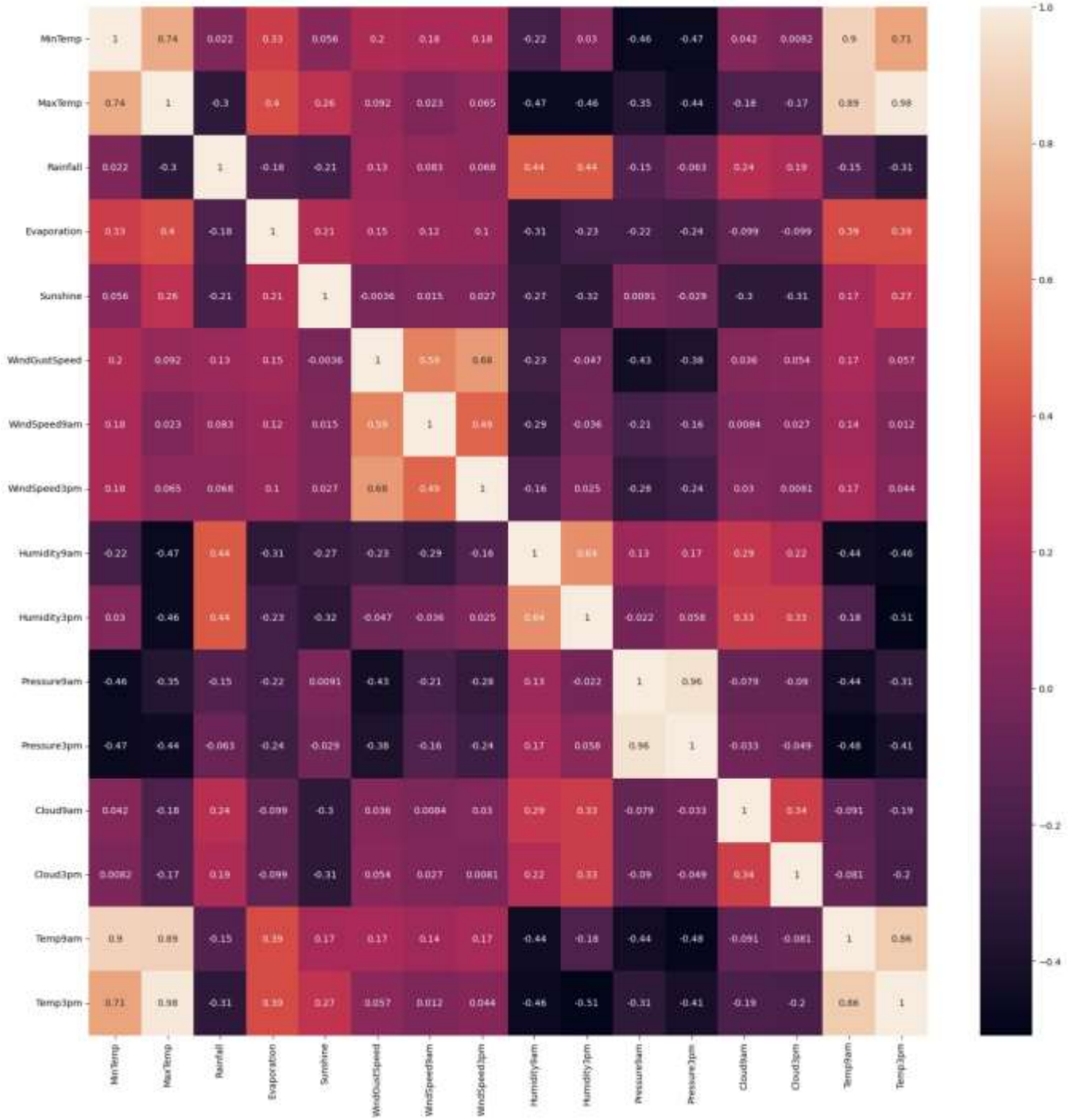


Figure 16. Correlation Heat map

The figure above shows the pairwise correlation between variables of our dataset through visual representation and hence can help in establishing the relation between the variables. It uses a color scale to represent the strength of correlation where Darker or more intense colors represent stronger correlations, while lighter or less intense colors represent weaker correlations. Positive correlations represent that the variables tend to increase or decrease together, while negative correlations represent that the variables move in opposite directions while variables with weak correlations may be independent of each other(as per Fig. 15 & 16).

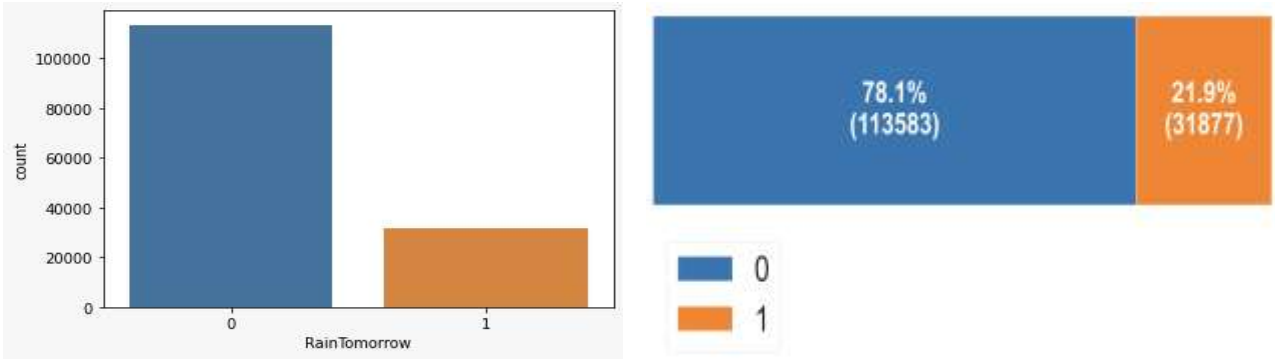


Figure 17. Common value plot of Rain Tomorrow

The Figure shown above shows the data in percentage of the number of days in which there is rain tomorrow. Here, 0 represents no rainfall and 1 represents rainfall (as per Fig. 17).

4.6. Accuracy of Prediction Model

```
In [69]:
y_pred = cat.predict(X_test)
print(confusion_matrix(y_test,y_pred))
print(accuracy_score(y_test,y_pred))
print(classification_report(y_test,y_pred))
```

```
[[21520  1197]
 [ 2777  3598]]
0.8633988725422796
              precision    recall  f1-score   support

           0       0.89      0.95      0.92     22717
           1       0.75      0.56      0.64      6375

    accuracy                           0.86     29092
   macro avg       0.82      0.76      0.78     29092
weighted avg       0.86      0.86      0.86     29092
```

```
In [70]:
metrics.plot_roc_curve(cat, X_test, y_test)
metrics.roc_auc_score(y_test, y_pred, average=None)
```

```
Out[70]: 0.7558501700807981
```

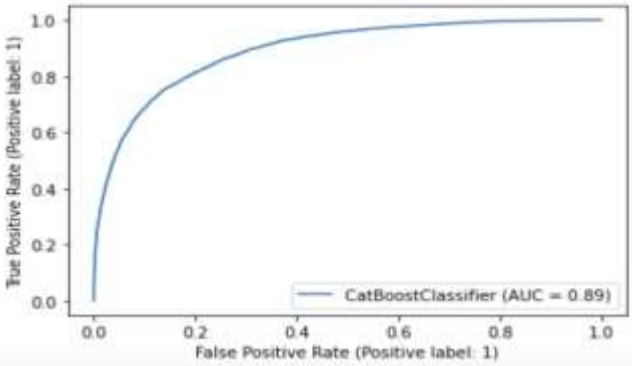


Figure 18. Accuracy of prediction model using CatBoost model

In the above figure the evaluation of the model is done using the CatBoost algorithm. The performance of the trained classifier is compared with the testing dataset. It uses evaluation metrics such as accuracy, precision, recall, or F1-score to assess the model's performance. The accuracy of this model comes out to be 89% (as per Fig. 18).

5. NOVELTIES

- We will provide accurate weather prediction to the user as well as including a graph that shows the certainty of a particular disease that you may get.
- We will provide a user-friendly website which requires some data to predict the upcoming weather. After filling it out, you will get your desired result.
- We also provide a special feature on the website that shows the disease that you can get on this upcoming day.
- It is helpful nowadays because mostly people want to know the upcoming weather conditions, and the bonus point here is that it also shows the possibility of several diseases that you can get.
- You can access it 24 hours a day, and it doesn't require any cost or package that shows in other web applications if you want to know more details about the upcoming weather-related conditions.

6. RECOMMENDATIONS

Improve public health awareness and education. Strengthen heat wave preparedness and response. Enhance cold weather resilience. Address the disproportionate impacts of climate change on vulnerable populations, including low-income communities, children, the elderly, and those with pre-existing health conditions, by implementing targeted interventions and equitable resource allocation. For research methodology, please consider comparing our chosen methodology with other potential solutions in the field. This comparative analysis will strengthen the robustness of our research (pl. refer Table 6).

Table 6. The Comparative Analysis of the Presented model with Current state of Art

Paper Title & Author	**Methodology**	**Result**
Weather Prediction Model using Advanced Machine Learning Techniques (Hemalatha, G. et al. 2021) [7].	Fully Connected Neural Network Model (FCNN).	With the IMD dataset as a test, the model generated an OA of 87.83%.
Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data (Biswas, M. et al. 2018) [2].	Regression Machine Learning, Naive bayes, Chi square, Java, Eclipse tool.	The web app predicts the weather of future
Machine Learning Applied to Weather Forecasting (Holmstrom, M. et al. 2016) [8].	Two algorithms were used for data analysis. Linear regression and functional regression.	Over longer time periods, this model has the potential to surpass the accuracy of professional forecasts.
Impacts of climate change on public health in India: future research directions (Bush, F. et al. 2011) [3].	Research based on the Joint Indo-U.S. Workshop on Climate Change and Health in 2009.	The workshop highlighted the urgent need for research, collaboration, and interventions to address the health impacts of climate change in India.
Weather Prediction Using Machine Learning (Patel, A. et al. 2021) [9].	They used machine learning algorithms in two categories: Supervised Learning and Unsupervised Learning.	The hypothesis function is used in showing the feature scaling in critical degrees of cubic or higher.

Machine Learning in Healthcare Data Analysis: A Survey (Dhillon, A. et al. 2019) [5].	They used machine learning algorithms, such as supervised, unsupervised, semi-supervised and reinforcement which were used in data forms.	To predict diseases on the basis of various forms of data.
Presented Approach of Climate Data Analysis	Here the authors have used Hexbin Plots for the Rain statistics	78.1% Accuracy have been identified.

7. FUTURE RESEARCH DIRECTIONS AND LIMITATIONS

The future research direction is to improve the data collection and its quality and to add on a voice command AI system. The enhancement of the weather prediction accuracy is directly depending on the reliability of the data. And the limitations of this climate data analysis is that it can't predict weather properly due to the variance of the data set as well as there are limited physical processes of traditional weather records.

7.1 Limitations

- It can't predict the weather accurately there due to variance in the data set.
- Need of more domain expertise which can help to improve the machine learning model and reduce its uncertainty estimations.
- Limited physical processes are affecting the accuracy due to the incorporation of traditional climate model physical equations that describe several processes such as atmospheric, oceanic, etc.
- Data quality and quantity also its limitations because obtaining accurate and reliable data is also challenging due to various factors such as observation in data gaps, and inconsistencies of historical data set.

7.2 Future Directions

- To improve the data collection and its quality reliability.
- Enhancing the weather prediction accuracy by collecting data from various forms.
- To add on a voice AI command system.
- Making its own API server that directly collects the data of weather records which make it easier to predict.

8. CONCLUSIONS

With the help of a machine learning algorithm the team was able to successfully analyze the climate data and also see if there is a correlation between climate and human health. The team used the linear regression approach of machine learning algorithm and analyzed the dataset and tried to predict the future weather conditions. The team also tried to relate the human health data with the various climate change conditions and concluded that climate change has an adequate effect on human health. As air pollution increases respiratory disease also emerges, as rainy seasons arrive dengue and malaria emerges and many more. The study also tries to predict the future weather conditions so that human health care is not at stake, health providers can also get benefit from the study and can work accordingly. The analysis can also be very helpful for the weather department and also for the agriculture sector. After analysis it is still uncertain how health diseases vary according to climate change.

Table 6: Impact of climate change on Human health in India

	Acute Diarrheal Diseases		**Malaria**		**Acute Respiratory Infection**		**Japanese Encephalitis**		**Viral Hepatitis**	
Year	**Cases**	**Deaths**	**Cases**	**Deaths**	**Cases**	**Deaths**	**Cases**	**Deaths**	**Cases**	**Deaths**

2005	8870507	2918	2031790	931	-	-	2593	556	153034	1038
2006	9289558	2787	2085484	1005	-	-	2061	479	149262	1147
2007	9441456	3475	1842019	973	-	-	1765	466	135859	914
2008	10510476	4709	1869403	1006	-	-	2568	707	151287	1006
2009	-	-	1915363	949	25571757	5223	1697	367	203939	1122
2010	-	-	1816569	963	-	-	6669	1682	-	-
2011	10079263	3124	1785129	1707	25807722	3467	2871	663	146433	673
2012	10993639	3603	1508927	1311	36171496	6948	4110	995	110055	544
2013	11408666	2865	1526210	1055	27451421	5321	3839	684	92291	536
2014	11224319	1762	1533169	1068	26544613	2813	4482	774	110586	586

Source: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3071055

The above shows the data of various diseases in India in the corresponding year. The table informs us that for a particular disease there were a given number of cases and out of them how many died in that year. This data helps us in correlating the health factor with climate change (Refer Table 6).

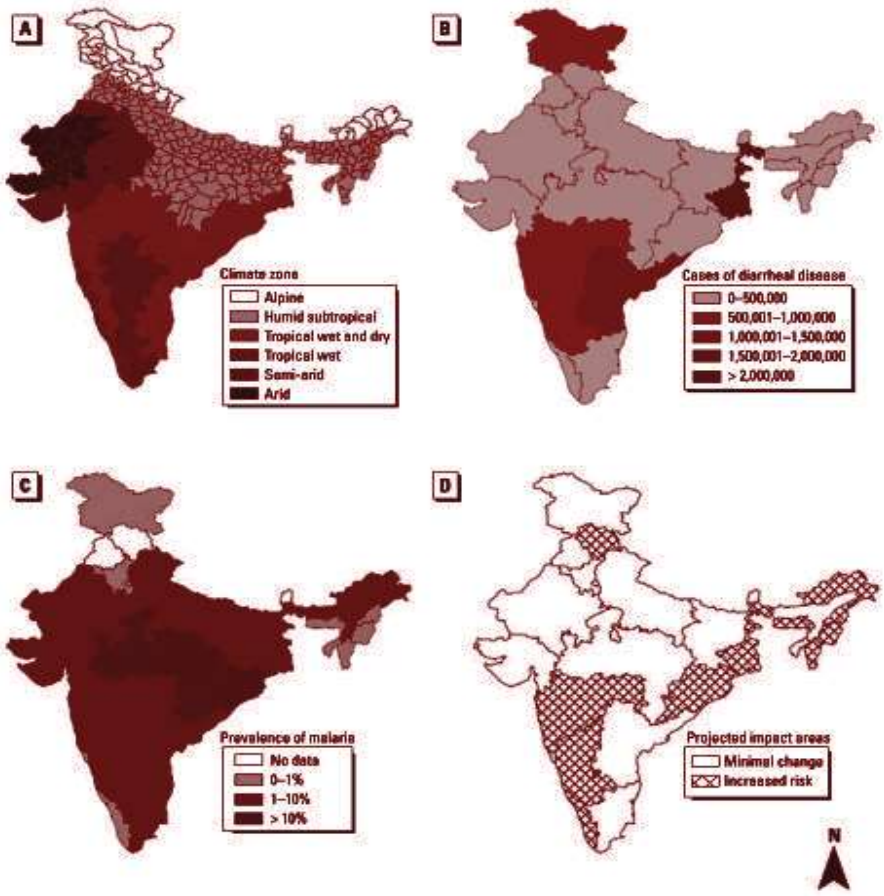


Figure 20: Interactions between climate and health in India
Source: //www.ncbi.nlm.nih.gov/pmc/articles/PMC3114809/

In the above figure, (A) the different climatic zones in India. (B) Cases of diarrhea across India. (C)Cases of malaria (on a

percentage basis) in different regions of India. (D) Prediction of certain areas in which the cases of malaria may increase due to change in climate (as per Fig. 20).

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ANNEXURES:

Key Terms and Definitions

- **Climate Change**: The long-term alteration of temperature and typical weather patterns in a place, resulting from natural processes or human activities, especially the emission of greenhouse gasses.
- **Greenhouse Gasses (GHGs)**: Gasses, such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gasses, that trap heat in the Earth's atmosphere and contribute to the greenhouse effect, leading to global warming.
- **Global Warming**: The ongoing increase in Earth's average temperature, primarily caused by the buildup of greenhouse gasses in the atmosphere due to human activities.
- **Heatwaves**: Extended periods of abnormally high temperatures, often accompanied by high humidity, that can pose serious health risks, including heat exhaustion, heatstroke, and other heat-related illnesses.
- **Air Pollution**: The presence of harmful substances or particles in the air, including pollutants like particulate matter, ozone, nitrogen dioxide, and sulfur dioxide. Climate change can influence air quality, exacerbating air pollution and its impacts on human health.
- **Respiratory Diseases**: Diseases affecting the lungs and respiratory system, such as asthma, chronic obstructive pulmonary disease (COPD), and respiratory infections, which can be worsened by air pollution and climate change-induced factors like increased pollen levels.
- **Vector-Borne Diseases**: Infectious diseases transmitted by vectors, such as mosquitoes, ticks, and fleas, which can be influenced by climate change, as warmer temperatures and altered precipitation patterns can affect the distribution, abundance, and behavior of disease-carrying vectors.
- **Waterborne Diseases**: Diseases caused by microorganisms that contaminate water sources, such as cholera, diarrhea, and other gastrointestinal illnesses. Climate change can impact the availability and quality of water, potentially affecting the spread of waterborne diseases.
- **Food Security**: The availability, access, and utilization of sufficient, safe, and nutritious food for all individuals. Climate

change can disrupt food production, decrease crop yields, and impact food availability and distribution, thereby threatening global food security.

- **Mental Health**: The psychological and emotional well-being of individuals. Climate change, through its impacts on extreme weather events, displacement, and ecological disruptions, can lead to increased stress, anxiety, depression, and other mental health issues.
- **Climate Resilience**: The capacity of individuals, communities, and systems to adapt, recover, and thrive in the face of climate change impacts. Enhancing resilience is essential for protecting human health from climate-related risks.
- **Sustainable Development**: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Addressing climate change and its impacts on human health is an integral part of sustainable development efforts.