PROJECT 2 – 2024

Effect of Climate change and Rainfall on Soil

Group - 01

Project Report

SUBMITTED IN PARTIAL FULFILLMENT REQUIREMENT

FOR THE AWARD OF DEGREE OF

BACHELOR OF TECHNOLOGY

SUBMITTED BY

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UNDER THE SUPERVISION OF

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SCHOOL OF ENGINEERING AND TECHNOLOGY

BML MUNJAL UNIVERSITY

FROM HERE TO THE WORLD

BML MUNJAL UNIVERSITY Gurugram, Haryana - 122413 May 2024

CANDIDATE'S DECLARATION

We Sayantan, Sejal Kumari, Manan Khandelwal hereby declare that the project entitled ″ Effect of Climate change and Rainfall on Soil Project" in fulfilment of completion of the 4th -semester course –PRJ 2 as part of the Bachelor of Technology (B. Tech) program at the School of Engineering and Technology, BML Munjal University is an authentic record of our work carried out under the supervision of

Dr. Hirdesh Pharasi. Due acknowledgments have been made in the text of the project to all other materials used.

This project was done in full compliance with the requirements and constraints of the prescribed curriculum.

Place: Gurugram

Date: 16th May 2024

SUPERVISOR'S DECLARATION

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Faculty Supervisor Name: Dr. Hirdesh Kumar Pharasi

Signature:

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1. ABSTRACT

Our extend points to investigate the impacts of climate alter and moving precipitation designs on soil wellbeing and efficiency. With climate alter driving to more extraordinary climate like dry spells, surges, and temperature changes, there are major suggestions for soil biological systems and rural frameworks.

We collected information from NASA partisan symbolism, government meteorological stations, and soil investigation reports. After preprocessing steps like taking care of lost information and expelling exceptions, we did exploratory information investigation (EDA). The EDA appeared expanding temperature patterns over time, relationships between tall temps and moo soil dampness, and a few districts encountering more aridity.

We compared the execution of distinctive machine learning models counting calculated relapse, SVR, and LSTM systems on this information. The LSTM show gave the finest comes about with an R^2 score of 0.82, indicating it might successfully capture the connections within the soil and climate information over time.

The discoveries highlight how climate alter contrarily impacts soil wellbeing through forms like disintegration, supplement exhaustion, and dampness misfortune. This underscores the require for moved forward soil administration hones adjusted to changing climate conditions. Our investigate provides insights to direct policymakers and raise mindfulness on economical horticulture within the confront of climate alter. Keeping up sound, beneficial soils is vital for long-term nourishment security.

Keywords:

Climate Variability, Environmental Dynamics, Comparative

Analysis, Data Visualization, Adaptive Strategies, Sustainable Development

2. INTRODUCTION

Welcome to our comprehensive project, "Effect of Climate change and Rainfall on Soil.” Climate alter is one of the foremost squeezing worldwide challenges of our time, with far-reaching suggestions for the environment, environments, and human social orders. Among the numerous results of climate alter, its affect on soil wellbeing and efficiency is particularly concerning. Soil, the establishment upon which terrestrial life depends, could be a complex and energetic framework that's personally connected to climate and precipitation designs.

Our project tackles the critical issue of climate change's impact on soil health. Climate change disrupts weather patterns, threatening soil, the foundation of life on land. Rising temperatures, altered rainfall, and other factors lead to soil degradation and loss of nutrients. This project uses data from NASA, government agencies, and soil studies to understand these complex relationships.

This project studies how climate change and rain patterns impact soil health. It explores solutions like improved soil management to counter these negative effects. By providing data-driven insights, the project aims to promote sustainable land use practices and raise awareness about soil's role in tackling climate change.

By combining cutting-edge information investigation methods, logical skill, and a profound understanding of the interconnected nature of climate alter and soil flow, this extend points to contribute to the worldwide effort to construct strength and advance maintainable hones within the confront of a changing climate.

3. LITERATURE REVIEW

Title of paper	Author of paper	Summary
NASA Power and surface weather stations on evapotranspiration estimation.	S.L.K. Rosa et al.	NASA Power's air temperature predictions are consistent across continental, polar, and semi-arid climates, but they deviate in tropical locations, particularly in wind speed and humidity estimates. Despite its limitations, it accurately calculates solar radiation and shows promise for estimating evapotranspiration, which is useful for water and soil engineering applications in agriculture.
Investigation of Long-Term Warming Trends Using NASA POWER Data: A Case Study in Al Buraimi, Sultanate of Oman	Osama A. Marzouk	The study found a considerable long-term increase in 2-meter air temperature, averaging 0.039°C per year and totaling approximately 1.5°C over four decades. Standard deviation remains constant. Temperature changes are seen between specific years. When compared to meteorological station readings, the dependability of NASA POWER in determining air temperature is validated.

Assessment of NASA POWER for Climate Change Analysis using the De Martonne Climate Index in Northern Peninsular Malaysia.	Puteri Nur Atiqah Bandira et al.	The study discovered significant agreement between NASA POWER and ground-based weather station data for rainfall and mean temperature in Northern Peninsular Malaysia (correlation coefficients of 0.78 and 0.87, respectively). The Dc index from NASA POWER agreed with ground data, confirming growing aridity in the region over 38 years, which is line with broader Southeast Asian patterns.

4. OBJECTIVES

- Effect on Soil Quality and Health
  Climate change alters soil quality and health by affecting soil moisture, nutrient availability, and microbial activity. Extreme weather events like drought and floods lead to soil compaction, erosion, and nutrient loss, diminishing soil fertility.

- Changes in Soil Composition
  Changes in rainfall and temperature impact soil composition. Intense rainfall can degrade soil structure and wash away nutrients, whereas arid conditions can lead to soil salinization. Both scenarios negatively affect soil productivity and ecosystem stability.

- Identify Mitigation Strategies
  Enhanced soil management practices such as crop rotation, cover cropping, and reduced tillage improve soil structure, boost organic matter, and enhance resilience to extreme weather, thereby maintaining soil health and productivity.

- Integration of Carbon Sequestration Techniques
  Techniques such as agroforestry, biochar application, and organic farming sequester carbon in the soil, improving soil fertility and structure while reducing atmospheric CO2 levels, helping to mitigate climate change effects.

- Inform Sustainable Practices
  Comprehensive soil health data inform sustainable agricultural policies. Policymakers use this data to promote soil conservation, efficient water use, and locally adapted sustainable farming practices.

- Promotion of Sustainable Land Use
  Sustainable land use policies should encourage practices that minimize soil degradation, such as conservation agriculture and reforestation. Providing incentives and funding for research into innovative soil management techniques is essential.

- Raise Awareness
  Educational campaigns and workshops can raise awareness among policymakers and stakeholders about the importance of integrating soil health into climate change policies, fostering a collaborative approach to soil conservation.

- Public Awareness Campaigns
  Public campaigns using various media can spread knowledge about the role of soil health in combating climate change, highlighting its benefits to food security, water quality, and ecosystem resilience.

5. DESCRIPTION OF DATA

The list of parameters that are used in our dataset to describe the Earth's surface and atmosphere. The parameters are:

1. **PRECTOTCORR (Precipitation Corrected)**: This parameter measures the bias-corrected average of total precipitation at the surface of the earth in water mass. It includes the water content in snow and provides a more accurate representation of precipitation by correcting any biases present in the raw precipitation data .
2. **TS (MERRA-2 Earth Skin Temperature)**: This parameter measures the temperature of the Earth's surface, also known as the land surface temperature (LST). LST is crucial for understanding a variety of environmental processes, such as energy balance, evapotranspiration, and plant growth. Accurate measurement of LST helps in weather prediction and climate modeling.
3. **T2M_RANGE (2-Meter Temperature Range)**: This parameter represents the range of temperatures measured at 2 meters above the ground surface. The temperature range provides insights into daily temperature variation, which is important for climate studies, agriculture, and human comfort assessments.
4. **T2MDEW (2-Meter Dew Point Temperature)**: This parameter measures the temperature at which air becomes saturated with moisture and dew forms at 2 meters above the ground surface. It is a critical factor for understanding humidity, condensation, and frost, which are important for agriculture, weather forecasting, and comfort levels .
5. **T2MWET (2-Meter Wet-bulb Temperature)**: This parameter is the temperature a parcel of air would have if it were cooled to saturation (100% humidity). It considers humidity and is measured at 2 meters above the ground. Wet-bulb temperature is vital for heat stress assessments and evaporative cooling analyses .
6. **QV2M (2-Meter Specific Humidity)**: This parameter measures the specific humidity, which is the mass of water vapor per unit mass of air, at 2 meters above the ground surface. Specific humidity is essential for understanding moisture content in the atmosphere, playing a significant role in weather prediction and climate models.
7. **PS (Surface Pressure)**: This parameter represents the atmospheric pressure at the Earth's surface. Surface pressure is an important variable in meteorology and climatology for understanding weather patterns, atmospheric circulation, and sea-level changes.
8. **WS2M_RANGE (2-Meter Wind Speed Range)**: This parameter calculates the range of wind speeds measured at 2 meters above the ground surface. It provides insights into

wind variability, which is crucial for renewable energy assessments, weather prediction, and structural engineering .

9. **WD2M (2-Meter Wind Direction)**: This parameter measures the direction from which the wind is blowing at 2 meters above the ground surface. Wind direction data are essential for meteorological analysis, pollution dispersion studies, and aviation.
10. **WS10M_RANGE (10-Meter Wind Speed Range)**: This parameter calculates the range of wind speeds measured at 10 meters above the ground surface. Wind speed range at this height is significant for wind energy potential assessments, meteorological studies, and transport modeling .
11. **WD10M (10-Meter Wind Direction)**: This parameter measures the direction from which the wind is blowing at 10 meters above the ground surface. Understanding wind direction at this height is crucial for wind energy applications, weather forecasting, and environmental monitoring .
12. **GWETPROF (Ground Wetness Profile)**: This parameter measures the moisture content in the soil profile. Soil moisture is critical for agricultural productivity, drought monitoring, and hydrological modeling. It provides insights into water availability for plant growth and ecosystem health .
13. **GWETROOT (Root Zone Ground Wetness)**: This parameter measures the moisture content in the root zone, crucial for assessing agricultural conditions and plant health. It helps in understanding water availability for crops and natural vegetation, aiding in irrigation planning and drought management .
14. **GWETTOP (Top Layer Ground Wetness)**: This parameter measures the moisture content in the top layer of the soil. It's important for surface runoff predictions, soil erosion studies, and initial conditions for atmospheric models. Top layer wetness also affects seed germination and early plant growth .

6. EDA (Exploratory Data Analysis)

To gain insights into the climate and soil data, we performed an extensive Exploratory Data Analysis (EDA). This process involved visualizing the data and identifying patterns, trends, and potential relationships between variables. The key steps and findings from the EDA are as follows:

Time-Series Plots

Precipitation: Similar to temperature, we visualized precipitation data over time. The plots highlighted significant variations in rainfall patterns, with some regions experiencing more frequent droughts or excessive rainfall events.

Correlation Analysis

We calculated the correlation coefficients between different variables, such as temperature, precipitation, soil moisture, and soil composition.

Significant positive correlations were found between temperature and soil moisture depletion, indicating that higher temperatures lead to increased soil dryness.

Negative correlations were observed between precipitation and soil erosion, suggesting that adequate rainfall can help mitigate soil erosion.

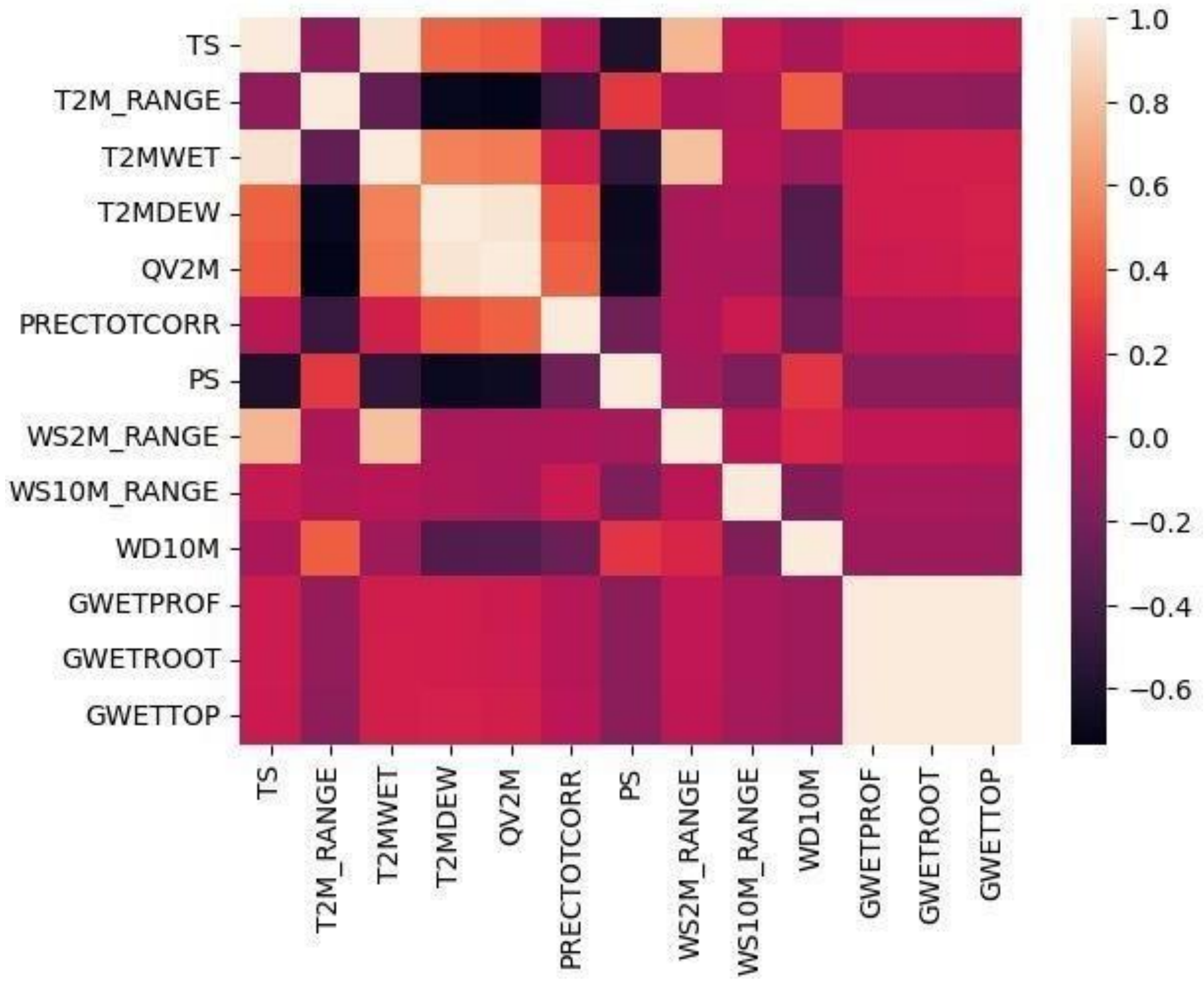

Figure 1corelation matrix of features

Spatial Analysis

We mapped climate data onto region-specific maps to identify hotspots or areas of concern.

Regions with the highest aridity levels and significant changes in soil moisture over time were highlighted.

Precipitation shifts were also detected while mapping the data.

Spatial correlation analysis was performed to explore the relationships between climate variables and other factors like vegetation cover or population density.

Outlier Detection

We identified and investigated outliers in the data, which could represent extreme weather events or measurement errors.

Techniques like box plots, scatter plots, and statistical tests were employed to detect and handle outliers appropriately.

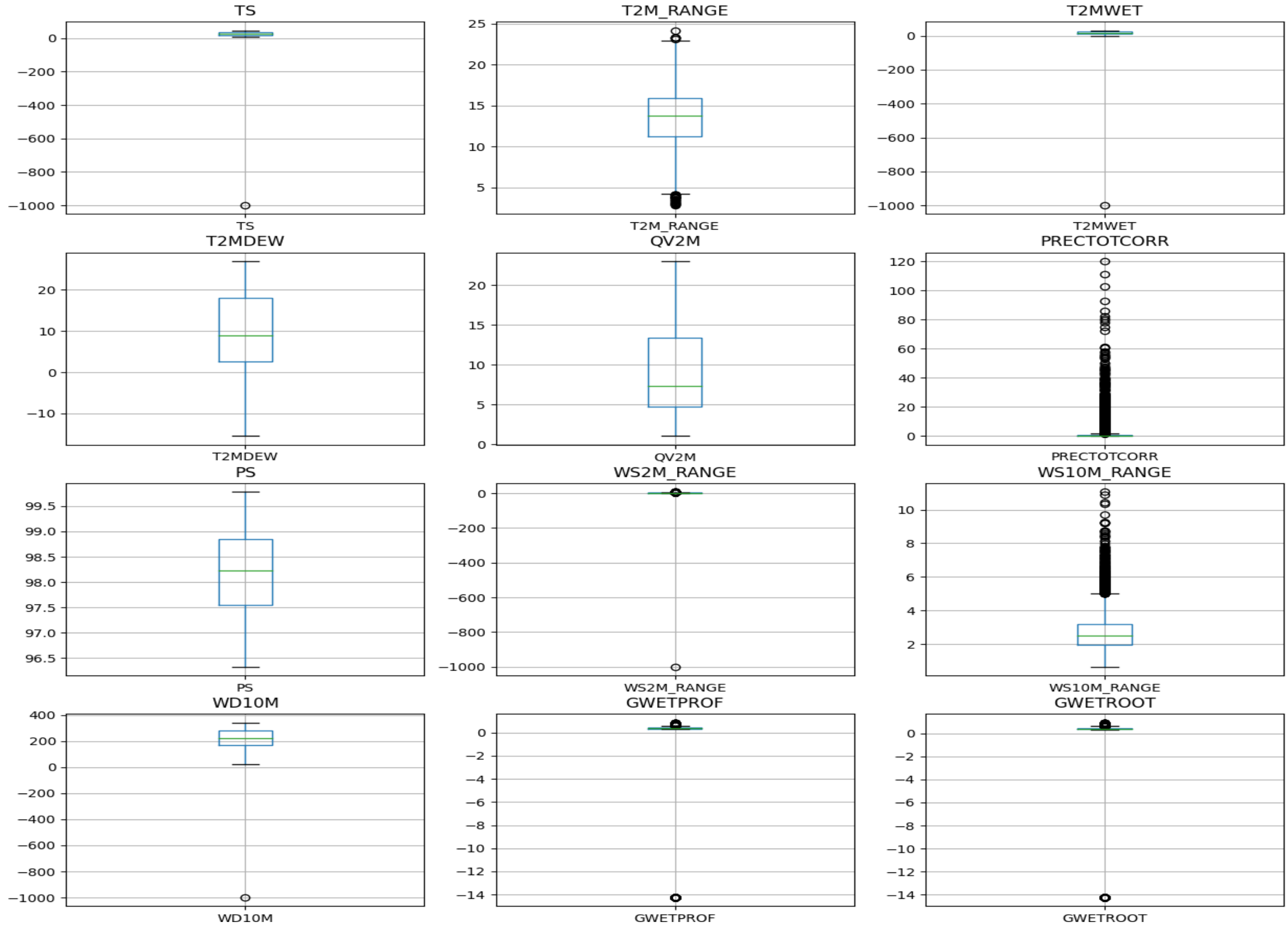

Figure 2 boxplot

Missing Data Handling

We addressed missing data points in the datasets using appropriate imputation techniques, such as mean imputation or interpolation methods.

The choice of imputation method depended on the nature of the missing data and the underlying patterns observed in the data.

7. RESULTS AND DISCUSSION

Change of rain pattern in Punjab:

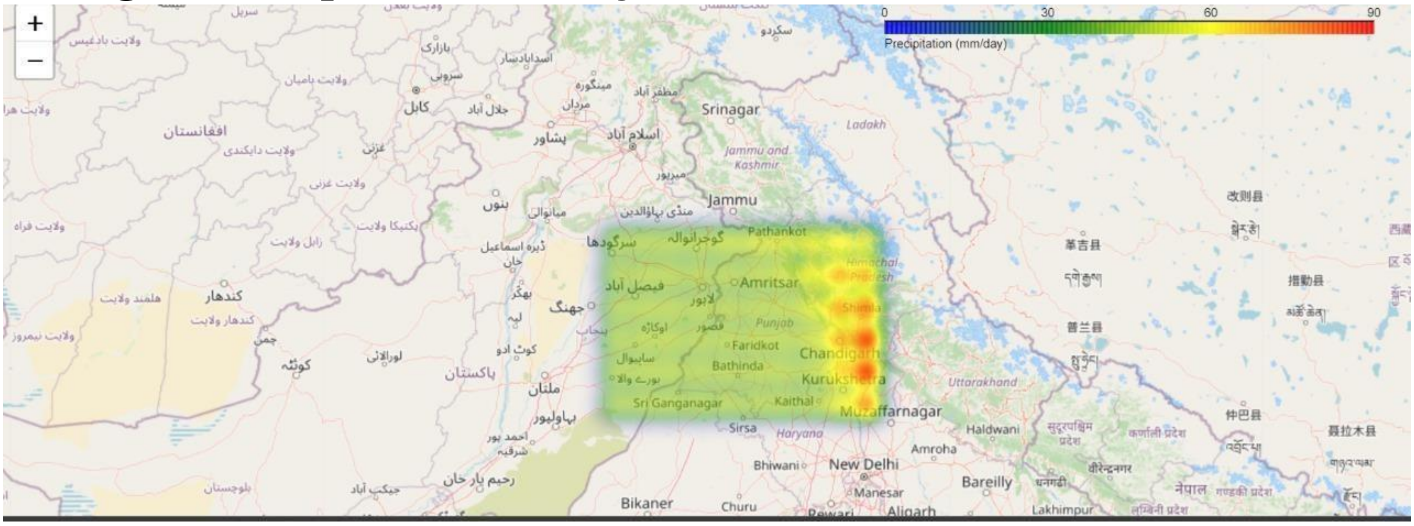

Figure 3 rainfall map of Punjab in 2010

The above choropleth map depicts the rainfall pattern of Punjab. The red area depicts the area with most rainfall. Currently it is centered towards Muzaffarnagar and Chandigarh.

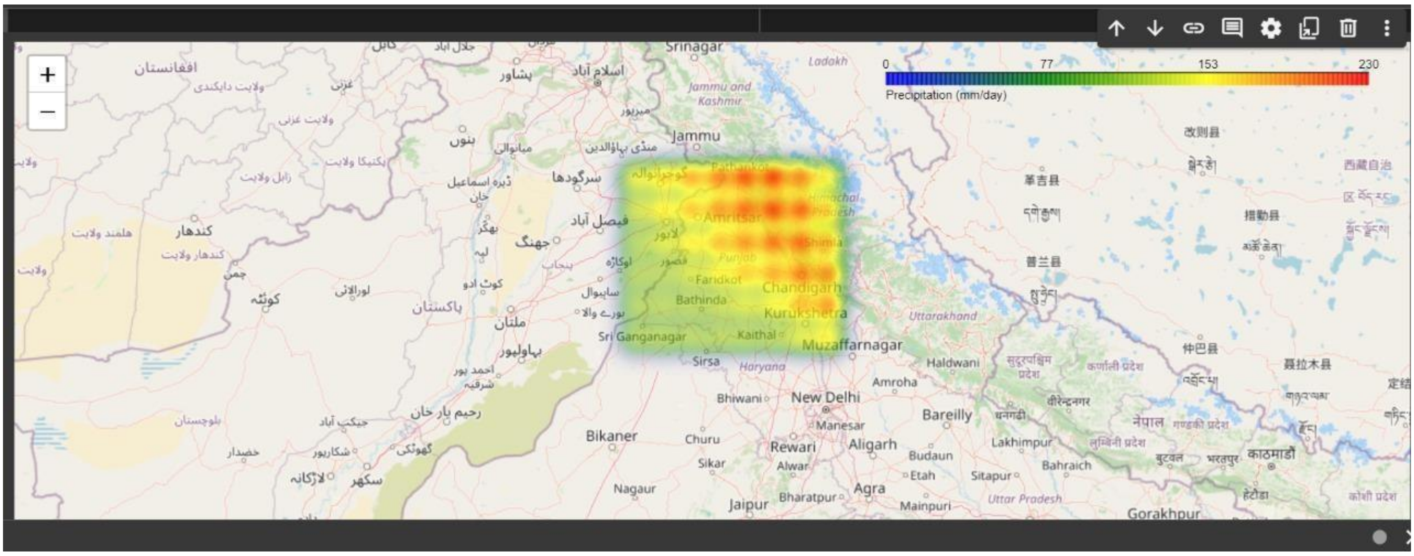

Figure 4 rainfall map of Punjab in 2022

In 2022 a shift in the rainfall pattern can be seen from Muzaffarnagar to Amritsar as red area expands towards right and gets dull near Muzaffarnagar. This phenomenon can be proven by time series plot of Amritsar and Muzaffarnagar.

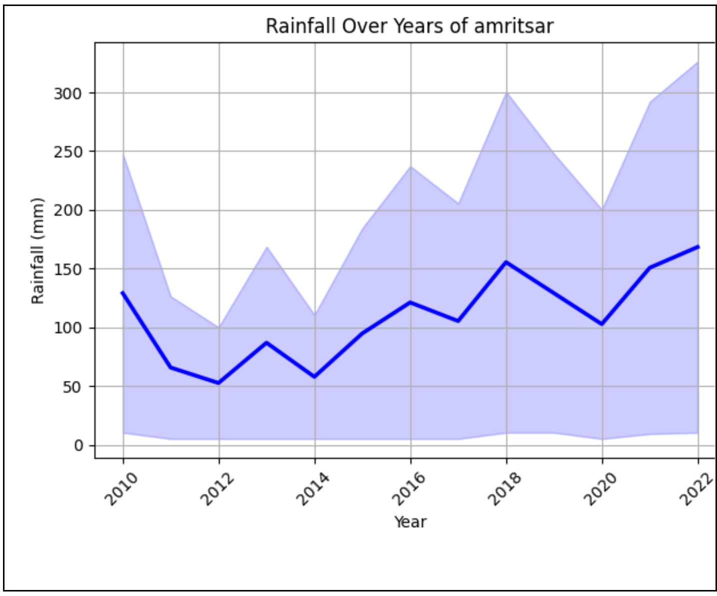

Figure 5 rainfall pattern of Muzaffarnagar

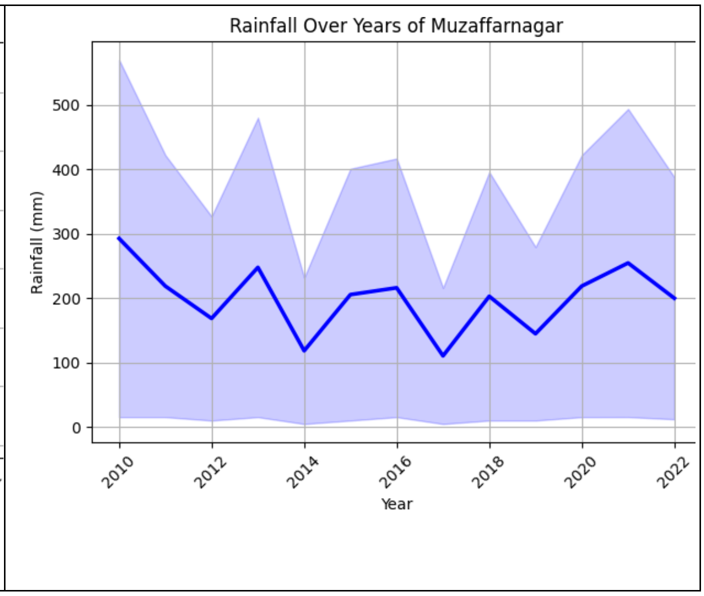

Figure 6 rainfall pattern of Amritsar

It is clearly seen a decline of rainfall in Muzaffarnagar, whereas increase in Amritsar. This proves the shift of pattern. This phenomenon occurred due to change in speed and time of westerly winds, which is responsible for bringing monsoon in north also this change in westerly wind occurred due to pollution in northern India especially near Delhi.

Change in soil moisture near Jodhpur:

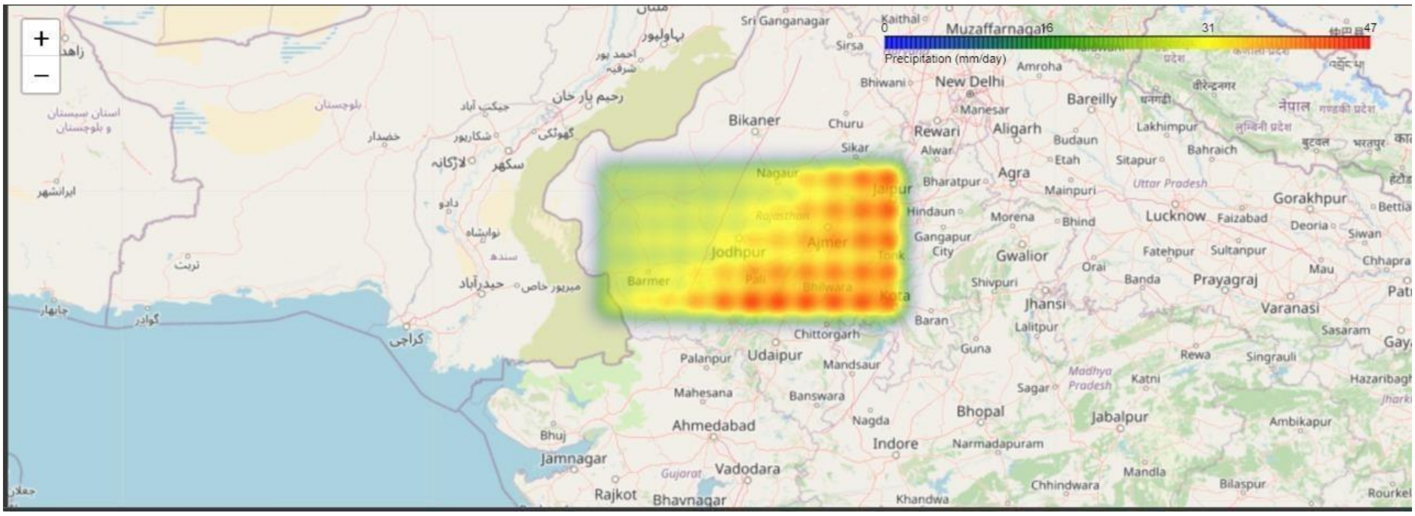

Figure 7 rainfall map of Rajasthan in 2010

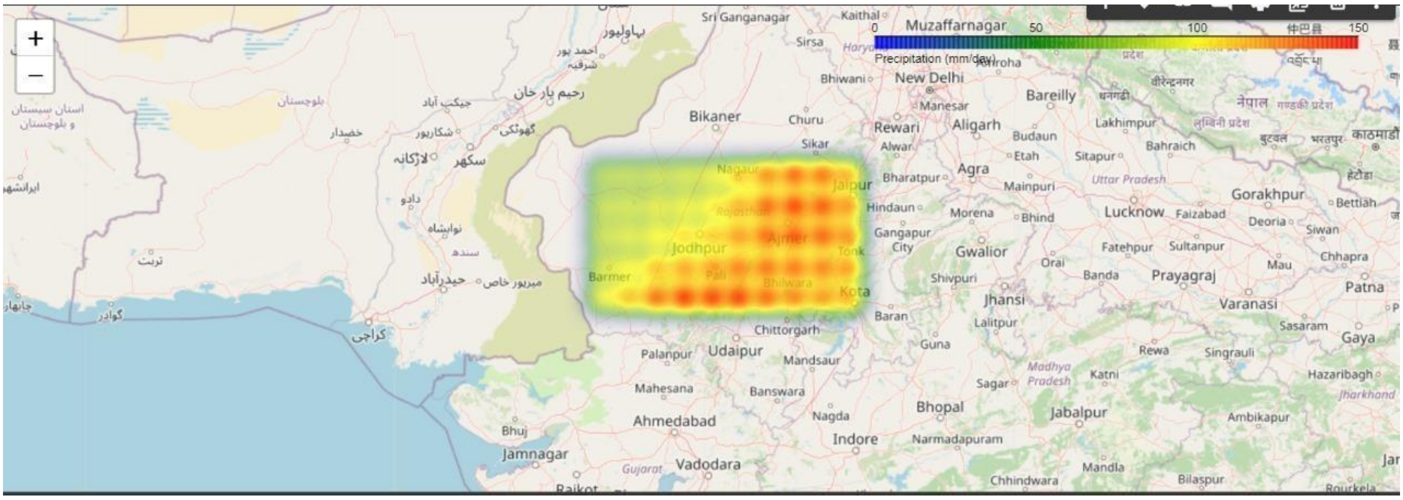

Figure 8 rainfall map of Rajasthan in 2022

From the above two graphs stating the rainfall patten of Rajasthan we can clearly see no Significant difference in the maps apart of the slight shift towards right. This tells us that there is no major change in rainfall.

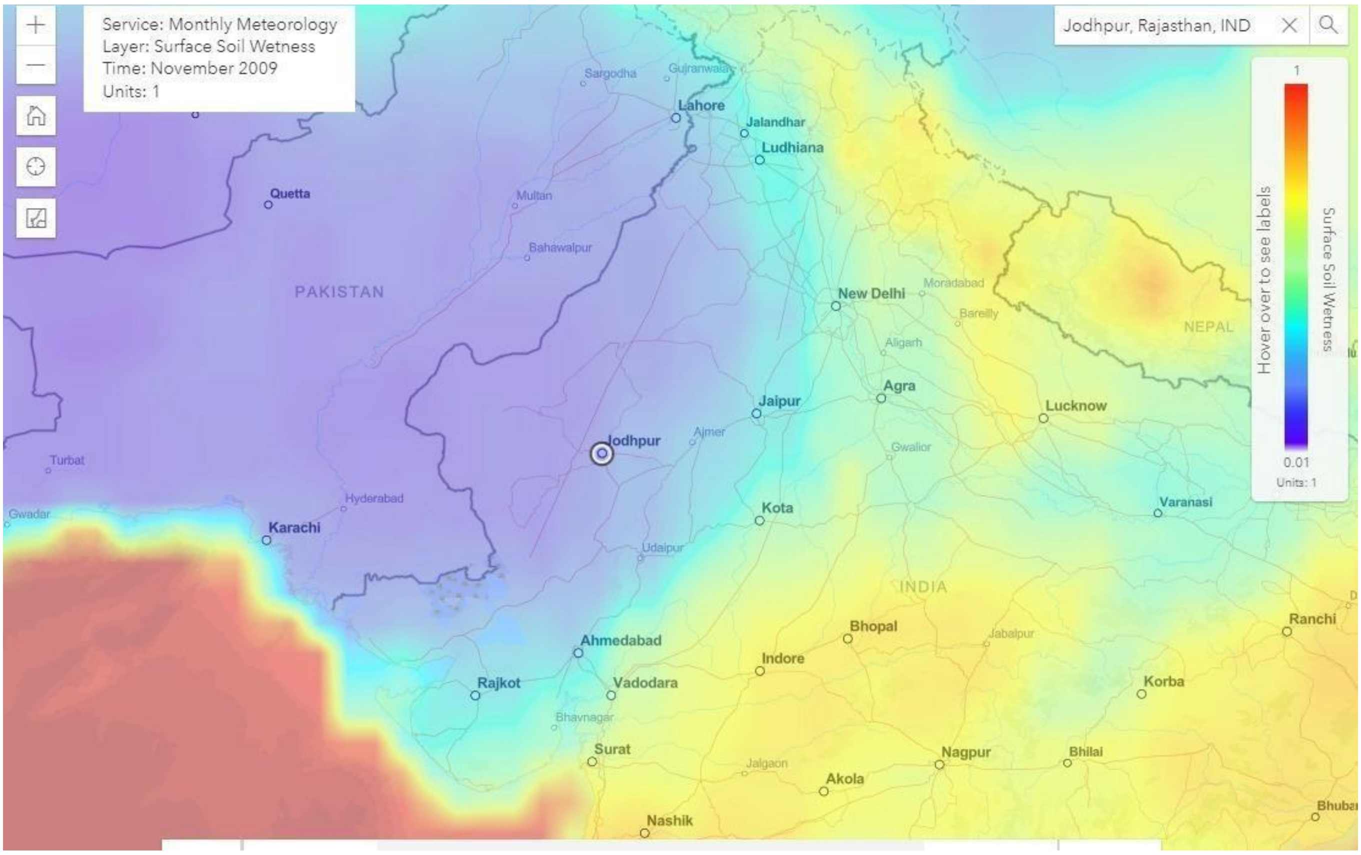

Figure 9 Rajasthan soil moisture content 2010

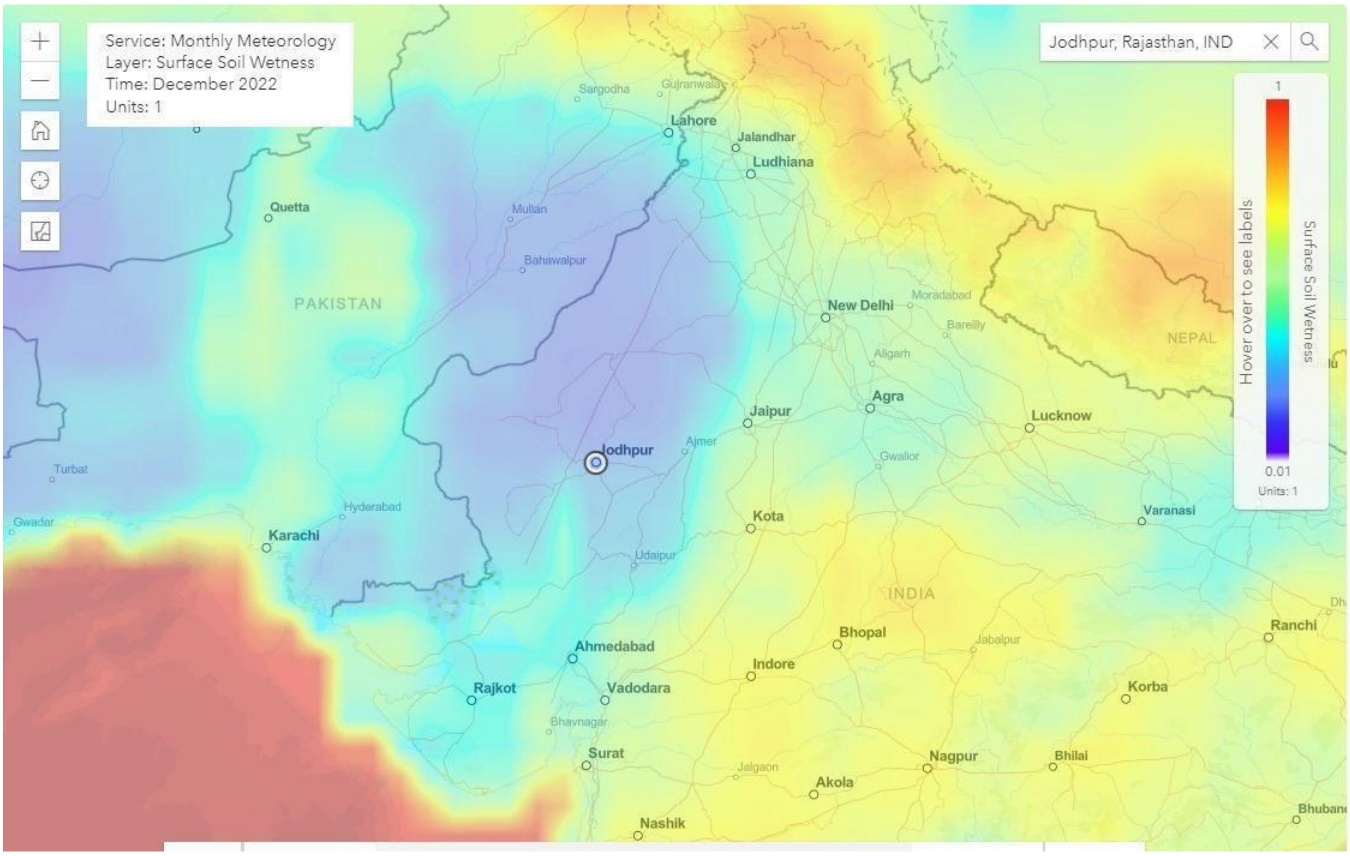

Figure 10 Rajasthan soil moisture content 2022

In the above two graphs we can see a major change in the soil wetness profile in the southern region of Jodhpur, soil moisture content from 2010 has a dark purple patch where as soil moisture content on 2022 near jodhpur has shown light blue colour. This indicates the improvement in soil moisture content in this region. Even the rainfall pattern remained same this phenomenon occurred due to construction of Indira Gandhi canal which caused improvement in vegetation in this region.

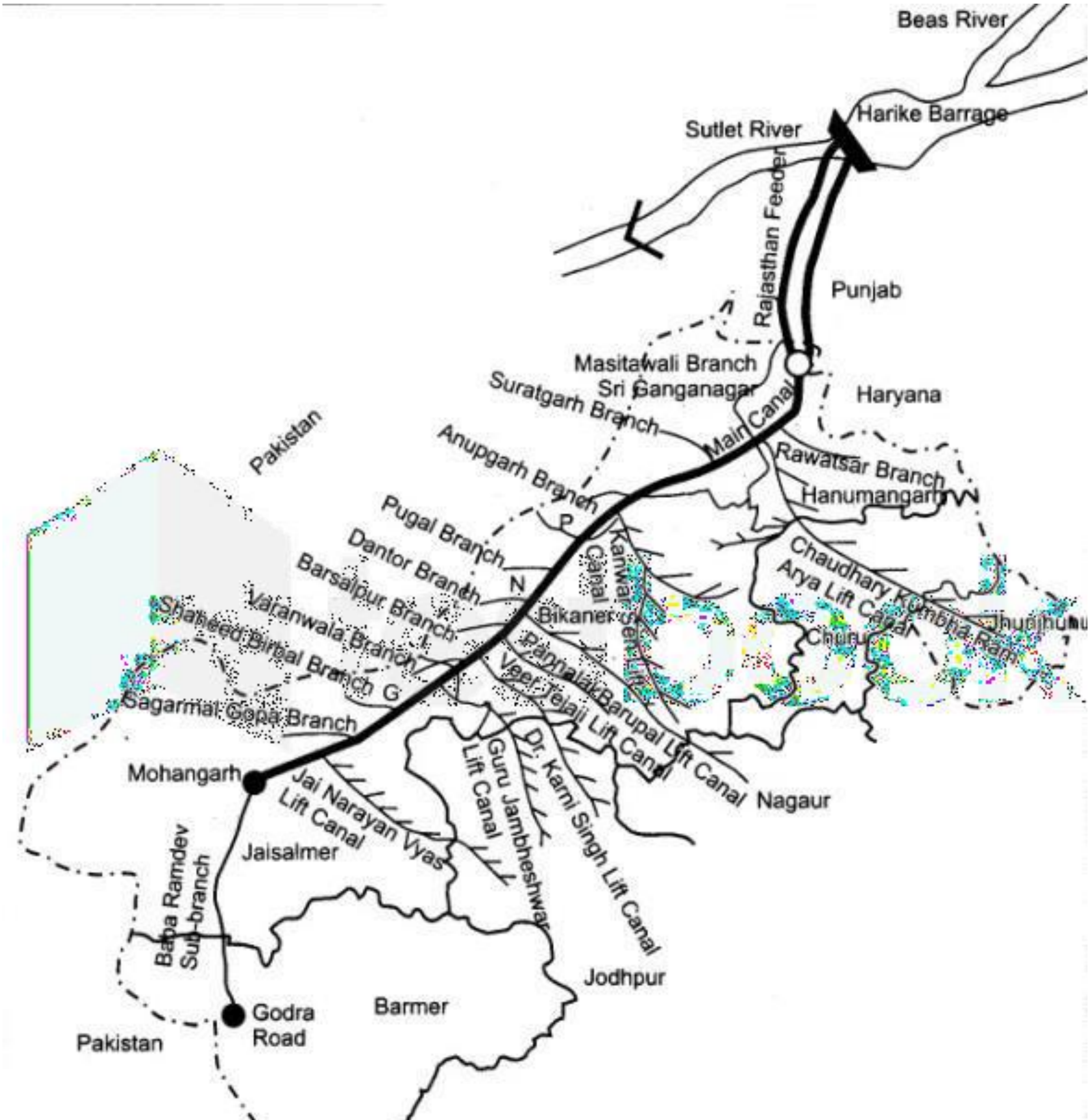

Figure 11 Indira Gandhi canal map

Increase of humidity in Uttar Pradesh:

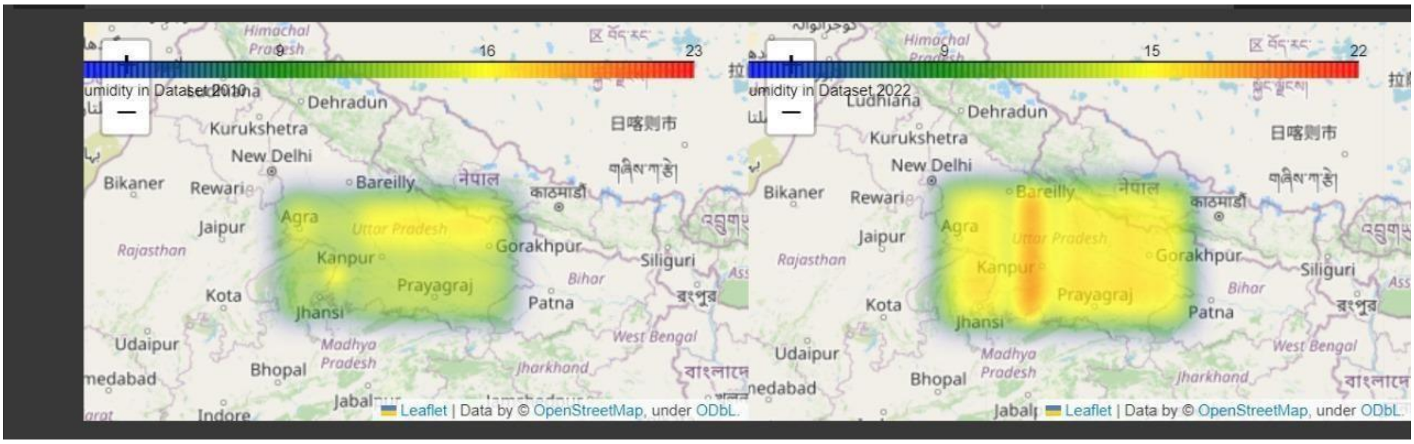

Figure 12 on left-humidity map of Uttar Pradesh (2010) , on right-humidity map of Uttar Pradesh (2022)

These contrasting choropleth maps of Uttar Pradesh unveil a surprising trend: increasing humidity. While intuitively this might seem beneficial, a closer look reveals a hidden threat. This rise in humidity disrupts the natural cycle, trapping moisture in the air and hindering evaporation rates. The consequence? Uneven rainfall distribution across the region. Despite the hot and humid feel, less water evaporates from the soil, leading to increased aridity. This creates a double whammy for farmers who face both water scarcity and heat stress for their crops.

Website for Soil and Rain prediction:

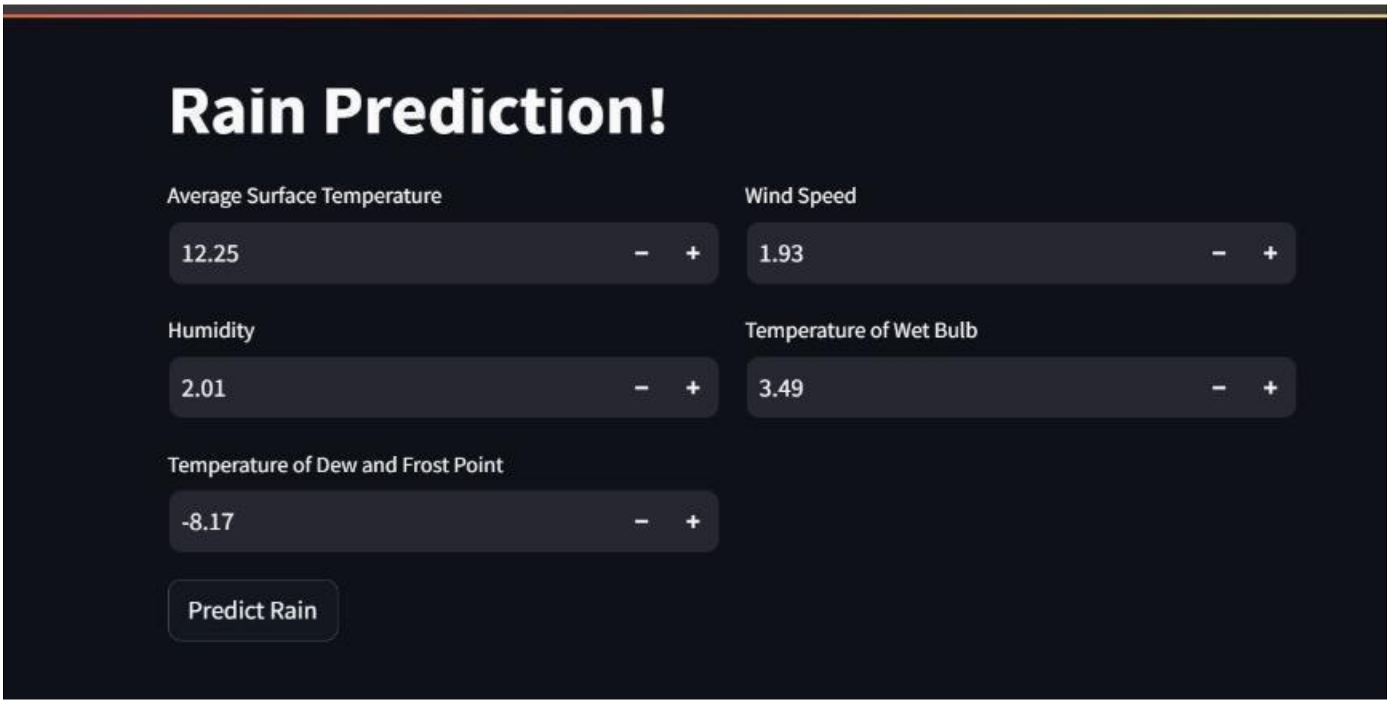

Figure 13 Rain prediction portal

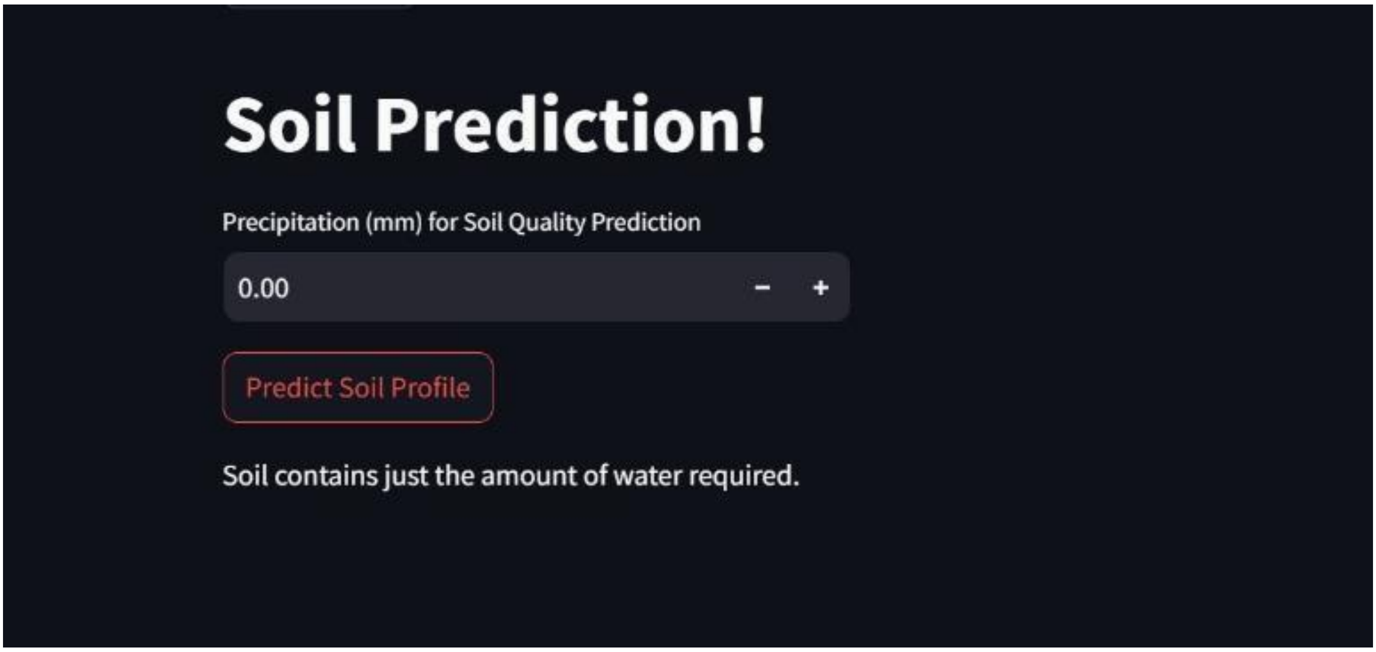

Figure 14 Soil Prediction portal

A portal is created for soil quality and rain prediction. It predicts the quality of soil using simple climatic conditions as an input and helps farmers to know better about their soil and how they can improve their quality. On the other hand rain predictor predicts weather it will rain or not so, it helps in planning the irrigation and method of irrigation.

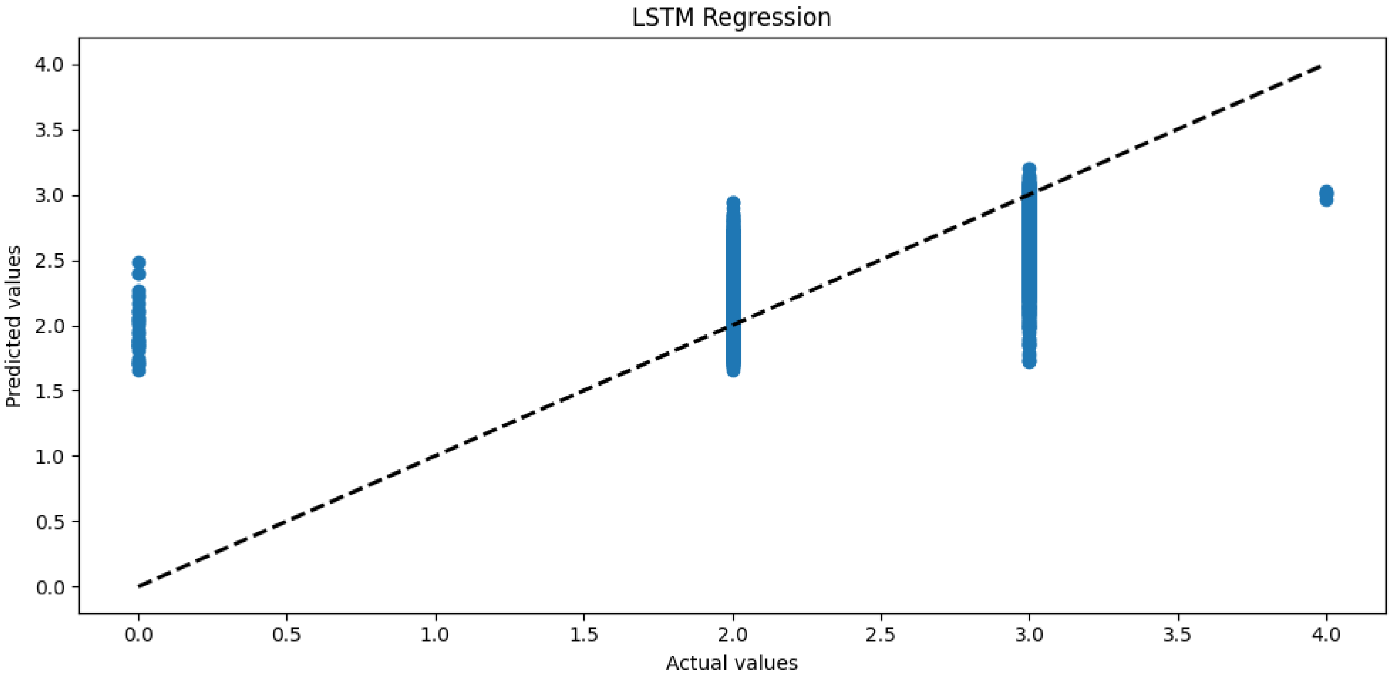

Figure 15 actual value vs predicted values

We chose LSTM model for prediction purpose as it remembers the old values and on the basis of it predicts the further outcome. It can be used for both regression and classification purpose. The above graph show the predicted values vs actual values. It helps to determine the accuracy of the model and data distribution

```
Mean Absolute Error: 0.2439610647527795
Mean Square Error: 0.1594865793659245
Root Mean Square Error: 0.3993577085344973
```

Above are the performance metrics of the LSTM model for the performance of the model.

8.FUTURE OUTLOOK

climate change portal

Visual Storytelling: The portal can become a central hub for presenting climate change information through compelling infographics, animations, and interactive data visualizations. This format is more engaging for the public compared to text-heavy reports.
Focus on Soil Health: Dedicate a section specifically to the impact of climate change on soil. Use the project's findings and data visualizations to showcase how altered rainfall patterns and temperature fluctuations affect soil moisture, erosion, and nutrient content.
Interactive Features: Consider incorporating interactive elements like quizzes, data overlays on maps, and user-friendly interfaces that allow people to explore how climate change affects their region.

Connecting the Dots:

Highlight the Soil-Climate Change Nexus: Clearly demonstrate the link between healthy soil and mitigating climate change. Show how improved soil management practices can store carbon, reduce erosion, and contribute to a more sustainable future.
Success Stories: Feature case studies of regions or communities that have successfully implemented sustainable land-use practices to improve soil health and combat climate change.

Call to Action: Motivate users to take action by providing clear and actionable steps they can adopt in their daily lives to contribute to a solution. This could include information on reducing personal carbon footprint, supporting sustainable agriculture practices, or advocating for climate-friendly policies.

Use of open Weather API

open Weather API can be integrated with soil predictor model which will seamlessly add values in the required columns making it accessible to everyone.

Diversifying the model:
Using mode data so that model can be released nationwide by helping the farmers and improving the crop quality and production which will overall boost the farmers income.

9. REFRENECES

Data Source: [1]*https://power.larc.nasa.gov/data-access-viewer/*

[2] *https://ieeexplore.ieee.org/abstract/document/9648428*

[3] https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/agronj2011.0038

[4] *https://ases.org/wp-content/uploads/2021/11/Near-Real%E2%80%90Time-Global-Radiation-and-Meteorology-Web-Services-Available-from-NASA-.pdf*

[5] http://www.embrapa.br/pab

[6] https://www.mdpi.com/2073-4395/11/6/1207

[7] https://iopscience.iop.org/article/10.1088/1755-1315/1238/1/012029

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