ET Partitioning

Using stable isotopes of oxygen and hydrogen

Web Development Project

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1. Introduction

1.1 Motivation

The irrigation water demand in the Ganga basin is among the highest in the world ($> 90\%$ of the total freshwater used in the basin). A major portion of the applied irrigation water eventually evapotranspires. The transpiration (T) component of the evapotranspiration (ET) is associated with crop productivity, while the undesirable soil evaporation (E) component represents losses. The knowledge of the relative magnitude of E and T fluxes in ET is therefore essential to design efficient irrigation techniques. The knowledge of ET partitioning is also crucial to understand the mechanism of energy and moisture transfer in the soil-plant-atmosphere continuum. In spite of its importance, few, if any, studies have investigated ET partitioning over the Ganga basin. In this project, we propose to estimate E and T fractions of ET by conducting field experiments at a site in the Upper Ganga Plains. A method based on stable isotopes of oxygen and hydrogen will be used. The main outcome of the project will be an understanding of the diurnal, inter- and intra- cropping seasonal variations in ET partitioning over rice-wheat system at the study site.

1.2 Problem Statement

In this section, we will discuss the problems at hand. The problem statements can be defined as follows:

- Develop a system to display various weather parameters (e.g., temperature, wind speed, relative humidity) and soil and plant properties for rice and wheat in graphical format.
- Comparison between different parameters like Temperature, Relative humidity etc between different sites (IIT Kanpur and bithoor).
- Implement automatic quality control for weather data to enable timely agricultural decisions (e.g. identifing missing data, range checks, step checks, internal consistancy checks)
- Automate the download of real-time data from the IoT device server and upload it to the web-based database server.

1.3 Relevance

The development of a system to accurately estimate and analyze the partitioning of evapotranspiration (ET) into transpiration (T) and evaporation (E) components in the Ganga basin holds significant real-world importance. Some key points are outlined below:

1. **Optimized Irrigation Practices:** Understanding the relative contributions of E and T to ET can lead to more efficient irrigation techniques. By reducing unnecessary soil evaporation and focusing on maximizing crop transpiration, water resources can be used more effectively.
2. **Enhanced Crop Productivity:** Knowledge of ET partitioning is crucial for optimizing crop productivity. By accurately assessing the water requirements of crops and minimizing water losses due to evaporation, agricultural yields for rice and wheat can be improved, contributing to food security in the region.

3. **Improved Water Resource Management:** Accurate ET partitioning data allows for better management of water resources in the Ganga basin. This understanding can support policy-making and water allocation decisions, ensuring that irrigation practices are sustainable and aligned with the region's water availability.

4. **Insight into Energy and Moisture Transfer:** The study provides valuable insights into the mechanisms of energy and moisture transfer in the soil-plant-atmosphere continuum. This knowledge can be applied to enhance climate models and improve predictions related to weather patterns and their impact on agricultural systems.

5. **Advancement of Research in the Region:** Conducting field experiments using stable isotopes of oxygen and hydrogen to estimate ET partitioning fills a research gap in the Ganga basin. This pioneering work can pave the way for further studies and technological advancements in agricultural and environmental science.

6. **Support for Sustainable Agricultural Practices:** The results from this project can inform and support the development of sustainable agricultural practices. By providing a detailed understanding of how water is utilized by crops, stakeholders can adopt practices that enhance resource efficiency and environmental conservation.

2. Software System Requirements

2.1 Functional Requirements

Functional requirement is the description of the services which are performed by the software system. Below followings are some functional requirements of the software systems:

1. **System should be able to fetch sensor's data.**
   Different sensors are installed on the sites. Data generated by these sensors are collected by a data logger or data acquisition system. So this data is need to be fetched by the system in real time from the remote site for the processing.

2. **Systems should be able to show large data in the form of graphs and tables.**
   Systems are using JS chart libraries which are efficient enough to show the large data in the form of graphs which is easily understandable by the users and these charts have minimal effect on the performance.

3. **Systems should be able to store the data in the database easily and securely.**
   As the system is using PostgreSQL database to store the data which is highly secure and easy to integrate.

4. **System provides options to select daily, weekly or custom to view the desired data.**
   We can see the weather station data based on daily average, weekly average or custom data within a choosen time interval for IIT kanpur and Bithoor sites.

5. **System should provide different option for seasonal data.**
   System provides different options for seasonal data like Crop Data (wheat) and Crop Data (Rice) for both IIT Kanpur and Bithoor sites.

6. **System should provide options to select Plot for IIT Kanpur site to see the desired data.**
   As IIT Kanpur site has 24 Plots for crop. System provides 24 options as button to choose different plots to show the soil moisture data and plant data as graphical format for iit kanpur site.

7. **System have no option to choose plot for Bithoor site.**
   As Bithoor site has only one plot for crop. there s no option to choose plot. All the data for soil moisture and plant properties are should be shown as year wise or time series as graphical format for Bithoor site.

8. **System should provide details of Soil properties for both sites.**
   System provides details of soil properties in table format and graphical format for IIT Kanpur and Bithoor sites.

9. **System should provide wind rose for wind speed for both sites.**
   System should provides wind rose graph for wind speed, average wind speed, max and min wind speed within a choosen time series for both sites.

10. **System should provide Comparison option between weather station data for both sites.**
    System provides option to choose weather station data catagory within a choosen time series for comparison between both sites.

2.2 Data Requirements

Data plays an important role in the system functioning. These systems can also be viewed as data visualization and analysis systems. Below are some of the data requirements for the systems:

1. **Data should be accurate and precise.**
   Data fetching from the sensors should be accurate. It should not have any erroneous elements.

2. **Data should be legitimate and valid.**
   Data have some range values for various parameters. The data from sensors should not have values outside that range. This makes the data valid and can be used for the systems.

3. **Data should have a desired format.**
   Data which is used by the system should have a particular format in terms of structure. Data should have values in their predefined range.

4. **Data should be reliable and consistent.**
   The system is using a database to store a single instance of the data to maintain consistency. The website and App will access data from this particular database.

5. **Data should be stored securely.**
   There are some confidential information stored in the database which can not be exposed outside. So the security of the data is also necessary.

6. **Data should be accessible to users.**
   Data can be fetched from the server and this data can be accessible and available for the users to view.

2.3 Performance Requirements

Performance is one of the key characteristics of a software system. It tells about how well the system perform under different circumstances. As the system is fetching and storing the large amount of data, so their performance also need to be maintained likewise. So below are some of the performance requirements for the systems:

1. Website should load in the real-time on the browser (use react app for frontend)
2. Systems should load the web pages in chunks in order to maintain the performance.
3. Multiple users should be able to access the same type of data from the database.
4. Websites are build with simple user interface which makes it user-friendly.
5. Write efficient query for fetching data from server.

3. Software Systems Overview

3.1 Technology Stack used in Software Systems

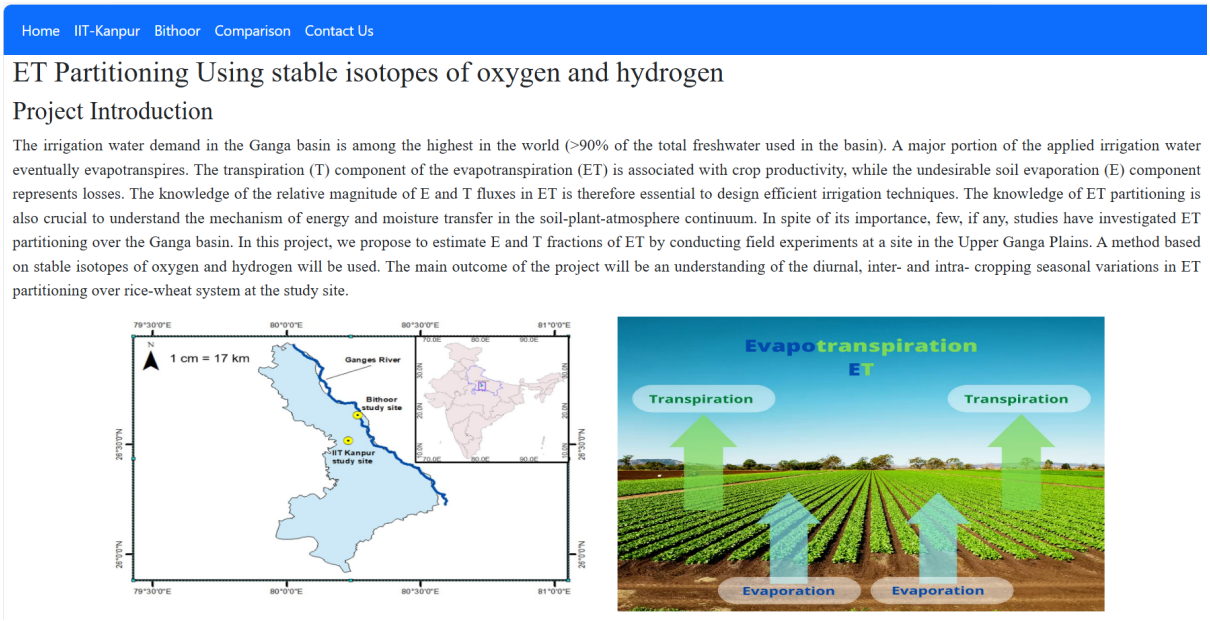
1. **Website Frontend**
   - **React:** Used for building efficient, scalable, and high-performance user interfaces.
   - **HTML:** Used to design the frontend portion of websites using a markup language.
   - **CSS:** Used for specifying the appearance and formatting of an HTML document.
   - **Bootstrap:** It provides the responsive frontend components for the website.
2. **Website Backend**
   - **Flask:** This framework is crucial for developing lightweight, flexible, and easy-to-deploy web applications and APIs.
   - **psycopg2:** Used psycopg2 python library to connect the database to the backend.
3. **Graph Framework**
   - **Highchart:** It is a freely available chart library, providing a number of maps and charts to use in the websites.
   - **HighchartsReact:** Used for creating wind rose chart for wind speed with the help of HighchartMore and Highchart libraries.
4. **Database Management System**
   - **PostgreSQL:** Used to store data as database server using pg-admin4.
5. **REST API**
   - **Flask**: Provides the requested data from the server in the platform independent JSON format.
   - **Postman:** Used to test APIs by sending requests and receiving responses.
6. **Data Processing System**
   - **Python:** Provides a lot of mathematical and scientific calculations libraries and efficient in data processing.

3.2 Scope of the Software Systems

1. Development of the website is to represent the data which can be accessed through the web browsers over the internet.
2. Designing of website desktop user interface
3. Developing APIs to fetch and store the data from the database.
4. Developing different algorithms to convert and process the raw data into the meaningful summary.

4. Website Overview:

4.1 Home

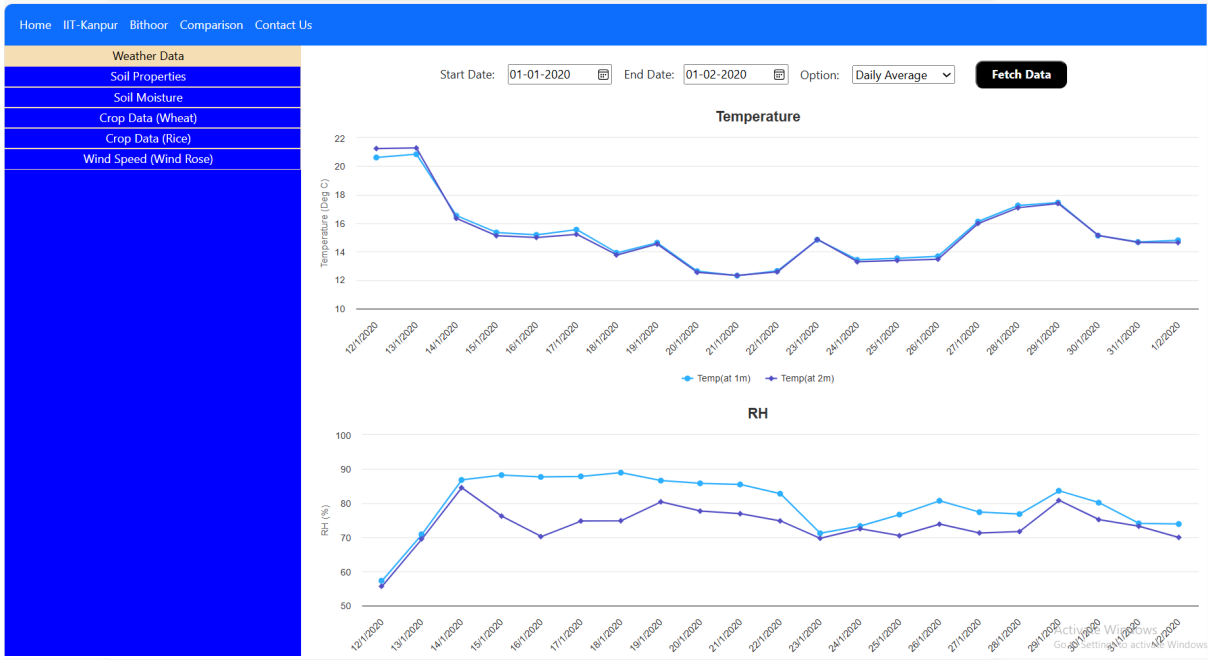


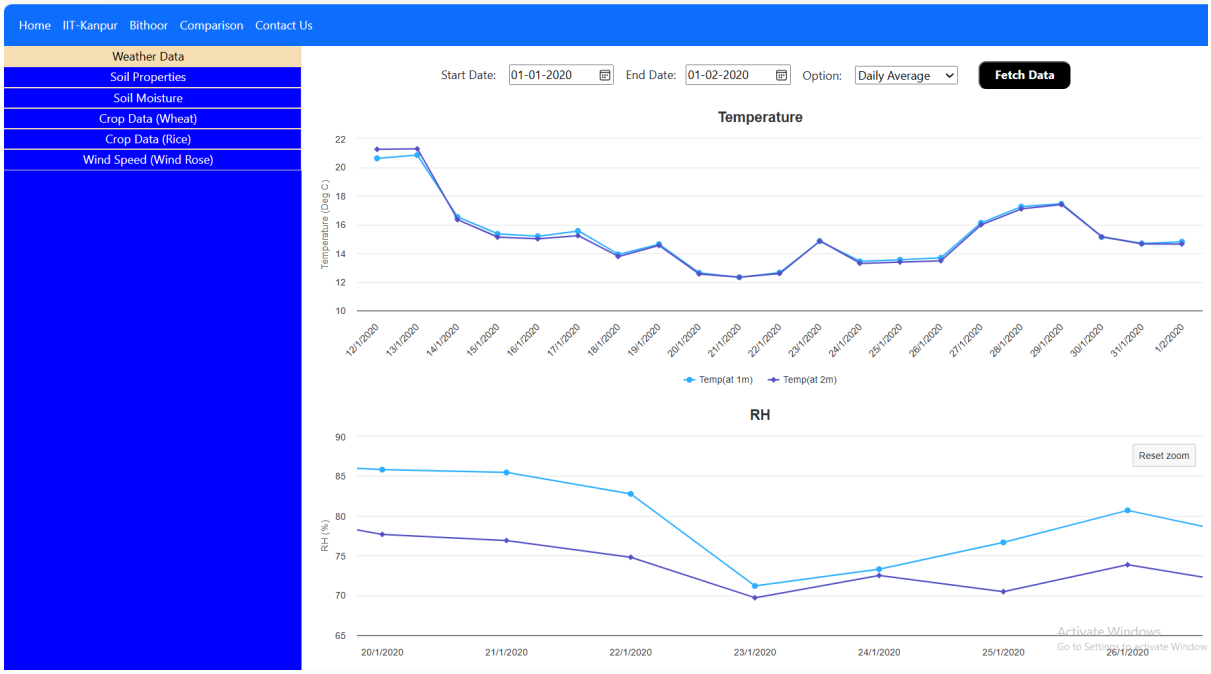
This is our homepage which introduces our project and shows working sites (IIT Kanpur and Bithoor) on map. It has a Navbar that contains 5 links:

1. Home
2. IIT-Kanpur
3. Bithoor
4. Comparison
5. Contact Us

4.2 IIT-Kanpur

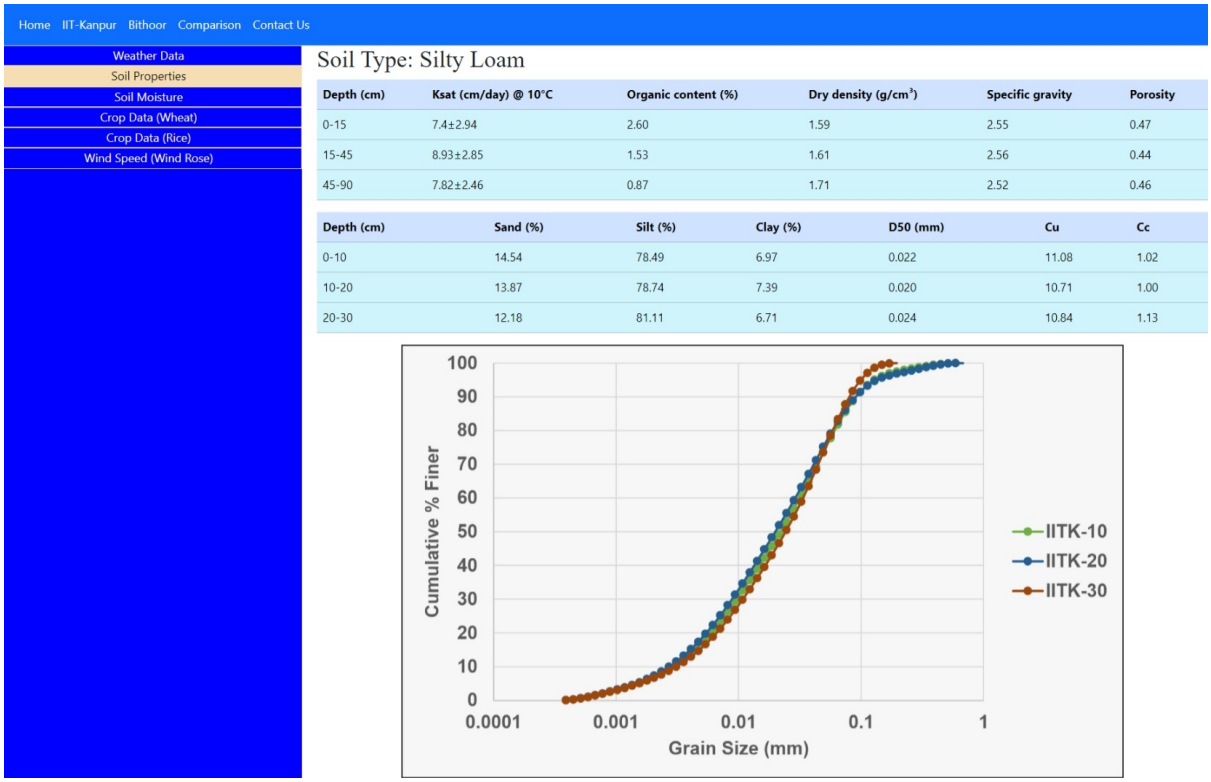
4.2.1 Weather Data





- User has option to choose custom data, daily average, and weekly average within choosen time interval and fetch data for different properties and able to see graph.
- User cannot choose invalid date otherwise he will get an error message.
- User can zoom in graph by selecting a particular area as shown in second picture.
- User has an option to reset zoom for that graph.
- The last three conditions are valid wherever applicable.

4.2.2 Soil Properties



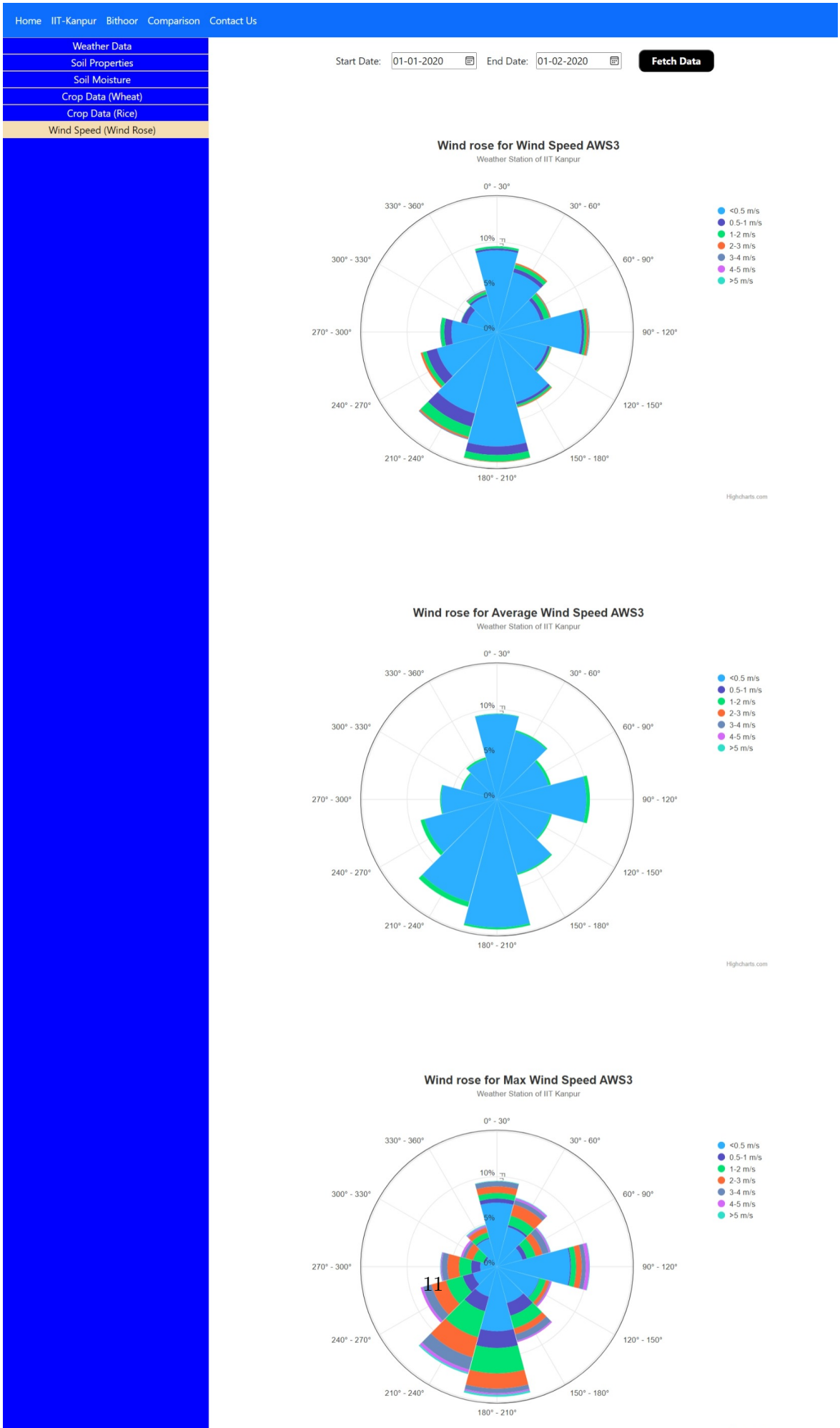
4.2.3 Soil Moisture

- User has option to choose different plot to see soil moisture property for different heights in choosen time series.

4.2.4 Crop Data (Wheat)

4.2.5 Crop Data (Rice)

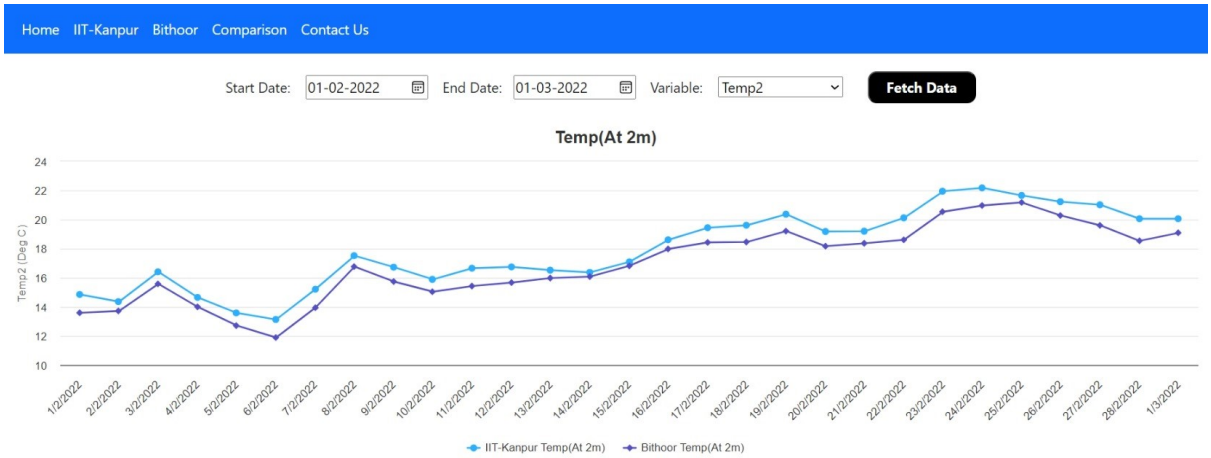
4.2.6 Wind Speed (Wind Rose)

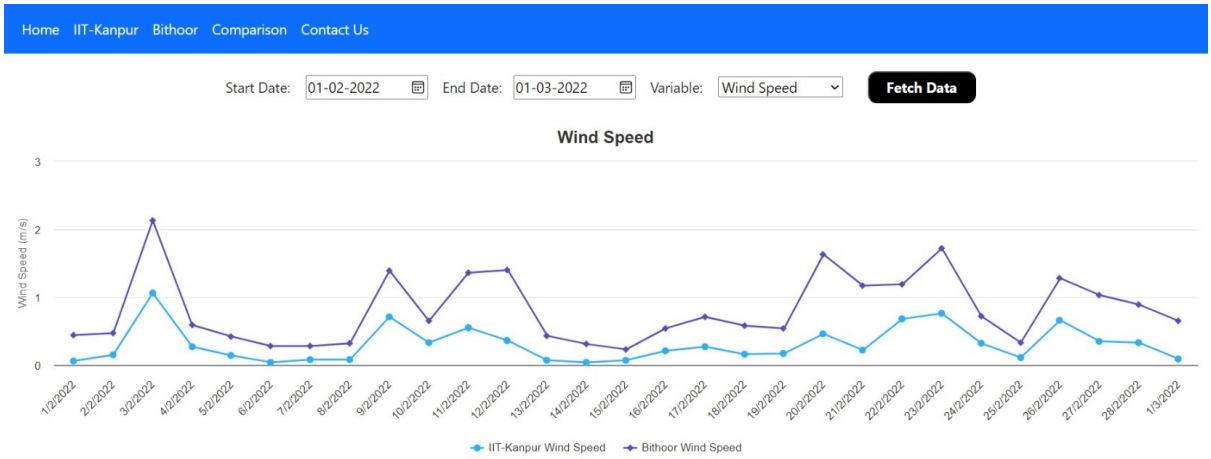


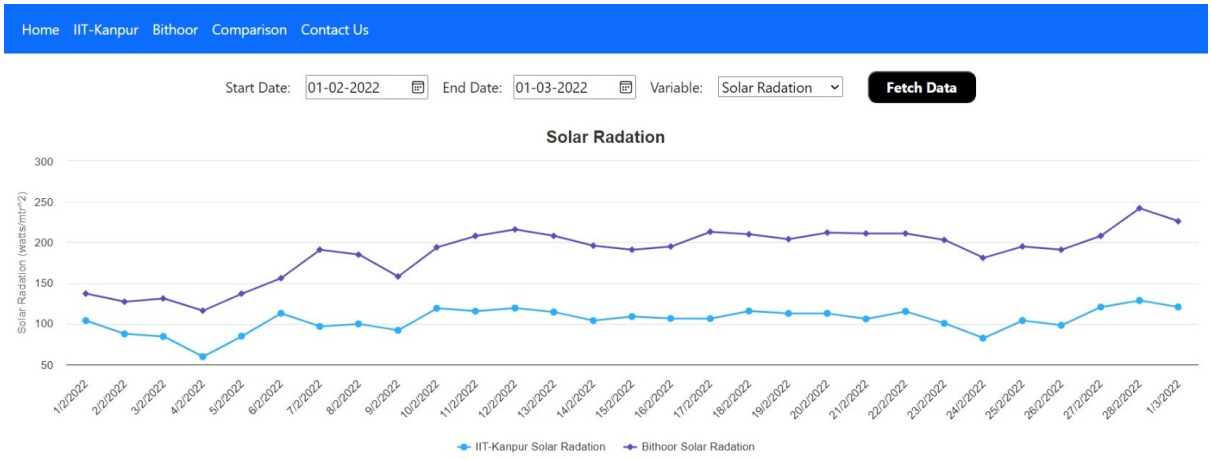
4.3 Bithoor

- All pages belonging to the Bithoor site are the same as those of the IIT Kanpur site.
- There is no option to choose a plot because it has a single plot.

4.4 Comparison







4.5 Contact Us