Project 1 Weather and Life Quality

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Adelaide Climate Analysis Report (May 2024 - April 2025)

Overview

A serious and considerable risk to humanity is posed by the continuous alteration of environmental conditions on Earth, attributed to climate change. The melting of glaciers and polar ice caps results in rising ocean levels. Lowland communities and even entire low-lying nations are consequently at risk of flooding. Alterations in temperature, including hotter summers and colder winters, exert influence upon crops, animal populations, storm patterns, and precipitation levels. Data encompassing wind speed, temperature, precipitation, and humidity are considered vital for the investigation. The collection of this data over a one-year period facilitates a more comprehensive understanding of seasonal weather variations. Gaining a general prognosis of future weather conditions is thereby rendered a useful tool for planning and preparing for adverse weather events.

The preparation of a report detailing the effects of climate change and assessing the feasibility of environmentally sustainable practices has been commissioned by the Bureau of Meteorology (BOM). Utilizing the data provided by the BOM, a feasibility analysis will be compiled. Among the concepts proposed for investigation is the collection of rainwater by households. However, the viability of this practice is contingent upon a sufficient volume of rainwater being collectable by households to satisfy demand. The generation of electricity will also be examined as a method for producing sustainable energy, with a particular focus on wind power. Furthermore, augmenting the green or sustainability rating of residential properties warrants consideration. This is due to the fact that a substantial reduction in household power consumption can significantly diminish the associated carbon footprint, thereby mitigating or even curtailing the effects of climate change.

Aim

The primary aim of this project was to conduct a comprehensive analysis of historical weather data for Adelaide, South Australia, spanning a full 12-month period from May 2024 to April 2025. The objective was to extract meaningful insights regarding temperature patterns, rainfall distribution, and wind speeds and to explore potential applications of this data, specifically assessing the suitability of the climate for outdoor comfort, the potential for domestic rainwater harvesting, and the theoretical feasibility of small-scale wind power generation.

Initial Investigations

Initial investigations involved identifying a reliable source of historical weather data for Adelaide. The Australian Bureau of Meteorology (BoM)[1] website was considered to be the prime source for this information. Data for the period covering May 2024 to April 2025 was located and downloaded. The data was provided in CSV format, with separate files for each month. To facilitate dynamic processing, each monthly CSV file was systematically renamed to follow a consistent `YY-MM.csv` format, where `YY` represents the year and `MM` the two-digit month number (e.g., `24-05.csv` for May 2024). The data contained daily records including maximum temperature, minimum temperature, rainfall, and wind speed, among other parameters.

Equipment List

The following equipment was used for this project:

- **Software:** MATLAB R2024b (or compatible version)
- **Data Source:** Australian Bureau of Meteorology website
- **Data Files:** Twelve CSV files containing daily weather data for Adelaide from May 2024 to April 2025.

Setup Procedures and Measurements

The setup involved loading the downloaded and renamed CSV files into the MATLAB environment. A MATLAB script was written to automate this process. The script iterated through the specified months (May 2024 to April 2025) and constructed the corresponding filename (`YY-MM.csv`). The `xlsread` function was used to read the data from each CSV file.

The extracted data for each month was stored in a structure variable called `weatherData`. The field names of this structure were dynamically generated based on the month and year (e.g., `May24`, `Jun24`, ..., `Apr25`). For each month's data, the relevant columns corresponding to maximum temperature, minimum temperature, rainfall, and wind speed were identified and accessed for analysis.

Measurements used in the analysis included:

- Maximum Daily Temperature (°C)
- Minimum Daily Temperature (°C)
- Daily Rainfall (mm)
- Daily Wind Speed (km/h)

Additional parameters used for calculations included:

- Assumed total roof area for rainwater harvesting (derived from room dimensions as per figure 1).
- Assumed cost of mains water per kiloliter.
- A simplified wind power generation curve relating wind speed to power output.

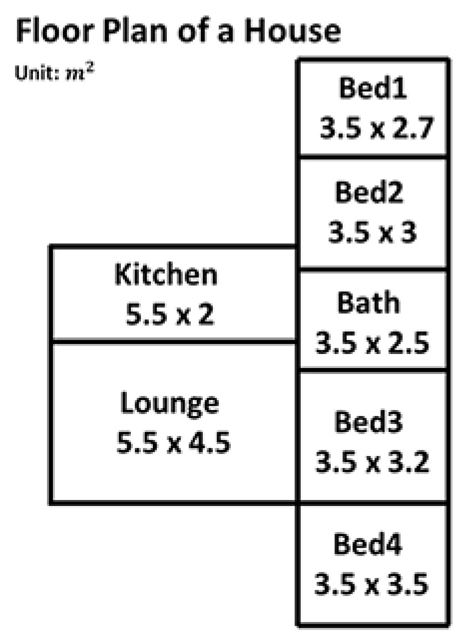

Figure 1. Floor plan of house

Data Analysis

Prior to any data analysis, the variables had to be named using the code below, where months and years were turned into cell arrays.

```
months = {'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec', 'Jan', 'Feb', 'Mar', 'Apr'};

MonthNum ={'05', '06', '07', '08', '09', '10', '11', '12', '01', '02', '03', '04'};

years = {'24', '24', '24', '24', '24', '24', '24', '24', '25', '25', '25', '25'};
```

Then the strings were formatted such that they became names to support variables and references to file names.

```
weatherData = struct();

for i = 1:length(months)

    filename = sprintf('%s-%s.csv', years{i}, MonthNum{i}(1:2));

    varName = sprintf('%s%s', months{i}, years{i});

    weatherData.(varName) = xlsread(filename);

end
```

Note that the line `varName = sprintf('%s%s', months{i}, years{i});` constructs variable names dynamically using elements from the `months` and `years` cell arrays. This method ensures the data structure is adaptable, allowing the user to easily incorporate new values or expand the database.
Using the above, the data analysis was conducted using the MATLAB script and focused on several key areas:

1. **Temperature Analysis:**
    - For each month, the daily maximum and minimum temperatures were plotted against the day of the month to visualize temperature fluctuations.

```
for i=1:length(months)

    subplot(3, 4, i); % Create a subplot for each month

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    % Plot the maximum and minimum temperatures

    hold on;

    plot(1:length(weatherData.(varName)(:,1)), weatherData.(varName)(:,1), 'r');
```

```
    plot(1:length(weatherData.(varName)(:,2)), weatherData.(varName)(:,2), 'b');

    hold off;

    xlabel('Day of the month');

    ylabel('Temperature (°C)');

    title(sprintf('%s %s', months{i}, years{i})); % Title of each subplot

    legend('Max Temp', 'Min Temp');

    grid on;

end
```

- Following the plotting, the script then calculated the number of "comfortable" days based on the defined temperature criteria (Min Temp >= 10°C and Max Temp <= 30°C). Iterating through each day of each month, checking if the temperature conditions met the criteria and marking the day in the `ComfortableTemperature` array.

```
ComfortableTemperature = zeros(length(months), maxDays); % Initialize the array to store comfortable temperature days

for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    % Check if the variable exists in the structure

    for d=1:length(weatherData.(varName)(:,1))

        if weatherData.(varName)(d,1)>=10 && weatherData.(varName)(d,2)<=30 % Fills the ComfortableTemperature array with 1 for comfortable days

            ComfortableTemperature(i, d)=1; % Comfortable day

        else

            ComfortableTemperature(i, d)=ComfortableTemperature(i, d); % Remains the same if not a comfortable day

        end

    end

    disp(['Comfortable days in ' months{i} ' ' years{i} ': ' num2str(numel(find(ComfortableTemperature(i, :) == 1)))]) % Display the number of comfortable days for each month

end
```

2. **Rainfall Analysis:**
   - Daily rainfall amounts for the entire year were plotted as a bar chart against the cumulative day of the year to show the distribution of rainfall throughout the 12-month period.

```
hold on

for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i});

    x_values = (cumulative_days(i)+1):cumulative_days(i+1);

    y_values = weatherData.(varName)(:,3);

    bar(x_values, y_values, 'FaceColor', colors(i,:), 'EdgeColor', 'none')

end
```

- Rainfall statistics were calculated by categorizing each day based on its rainfall amount:
  - No Rain (0 mm)
  - Normal Rain (> 0 mm and <= 10 mm)
  - Heavy Rain (> 10 mm)
- The total number of days in each category was determined and reported.
- The total annual rainfall in millimeters was calculated by summing the daily rainfall amounts over the entire year.

```
for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    rain_data = weatherData.(varName)(:,3); % Extract rainfall data

    NoRain=NoRain+numel(find((weatherData.(varName)(:,3))==0)); % Count days with no rain

    NormalRain = NormalRain + sum((rain_data > 0) & (rain_data <= 10)); % Count days with 
normal rain

    HeavyRain=HeavyRain+numel(find((weatherData.(varName)(:,3))>10)); % Count days with heavy 
rain

    TotalRain=TotalRain+sum(weatherData.(varName)(:,3)); % Calculate total rainfall

end
```

- Using an assumed total roof area (calculated from provided room dimensions from figure 1), the potential volume of rainwater that could be collected annually was estimated. This volume was then used, along with an assumed cost of mains water, to calculate the potential annual cost savings from rainwater harvesting.
  - Dimensions and cost per kiloliter were hardcoded into the script due to the values being fixed.

```
Bed1Area=3.5*2.7;

Bed2Area=3.5*3;

Bed3Area=3.5*3.2;
```

```
Bed4Area=3.5*3.5;

BathArea=3.5*2.5;

KitechenArea=5.5*2;

LoungeArea=5.5*4.5;

TotalArea=Bed1Area+Bed2Area+Bed3Area+Bed4Area+BathArea+KitechenArea+LoungeArea; % Calculate
total area

RainVolume=TotalRain*TotalArea/1000; % Convert mm to m^3

CostPerKL=2.251;

AnnualCostSavings=CostPerKL*RainVolume;

disp(['Annual Cost Savings: $' num2str(AnnualCostSavings)])
```

- A pie chart was generated to visually represent the proportion of days falling into the "No Rain", "Normal Rain", and "Heavy Rain" categories.

```
pie_chart = [NoRain, NormalRain, HeavyRain];

labels = cell(1,3); % Create labels for the pie chart

for i = 1:3

    labels{i} = sprintf('%s: %.1f%%', rain_strings{i}, percentages(i)); % Format labels

end

figure(4)

pie(pie_chart, labels)

title('Rainfall Distribution')
```

3. **Wind Speed Analysis:**
    - Daily wind speeds for the entire year were plotted against the cumulative day of the year to visualize wind patterns.

```
for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    x_values = (cumulative_days(i)+1):cumulative_days(i+1); % Get x values

    y_values = weatherData.(varName)(:,7); % Get y values

    h_lines(i) = plot(x_values, y_values, 'Color', colors(i,:)); % Plot the wind speed

end
```

- A simplified wind power generation curve was provided, relating specific wind speeds to a theoretical power output in kilowatts (kW), the chart was turned into an x & y matrix.

```
PowerGeneration=[0 0 1 0.9 0 0]; % Initialize the array to store power generation values

Windspeed=[0 13 50 100 100 130]; % Initialize the array to store wind speed values
```

- The script also included a function to estimate the instantaneous power generation for any given wind speed input by performing linear interpolation between the points on the provided power 'curve'. The user is prompted for a value for wind speed; then using this value, instantaneous power generation can be calculated.

```
Wind_Input=input('Enter wind speed (km/h): ');

InstantanousPowerGeneration_Output=0; % Initialize the output variable

for i=1:length(Windspeed)-1

    if Wind_Input>=Windspeed(i) && Wind_Input<Windspeed(i+1) % Check if wind speed is within range


InstantanousPowerGeneration_Output=PowerGeneration(i)+(PowerGeneration(i+1)-PowerGeneration(i))*((Wind_Input-Windspeed(i))/(Windspeed(i+1)-Windspeed(i))); % Linear interpolation

        break % Exit loop if wind speed is found

    end

end
```

This turns the array into a general gradient formula $m = \frac{y_2 - y_1}{x_2 - x_1}$, which then plugs m back into $y = mx + c$ to solve for y, or in this case, the 'instantaneous power generation output.'

- Should there be any values outside of the range where wind speed could generate energy, it was highlighted with a white star on the wind plot graph. The loop below searches for values outside the maximum and minimum index on the wind speed provided by the power curve.

```
star_x = [];

star_y = [];

for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    x_values = (cumulative_days(i)+1):cumulative_days(i+1); % Get x values

    y_values = weatherData.(varName)(:,7); % Get y values
```

```
    for d=1:length(y_values)

        if y_values(d)<= Windspeed(MinWindSpeedIndex) || y_values(d)>=
Windspeed(MaxWindSpeedIndex) % Check if wind speed is outside operational range (0-100 km/h)

            star_x = [star_x, cumulative_days(i)+d]; % Append x value

            star_y = [star_y, y_values(d)]; % Append y value

        end

    end

end
```

- Using the aforementioned power generation-wind speed arrays and the datasets provided by the BOM, a bar chart of power generation (kW) of per day can be graphed by cross-referencing the two arrays.

```
hold on

for i=1:length(months)

    varName = sprintf('%s%s', months{i}, years{i}); % Create variable name

    x_values = (cumulative_days(i)+1):cumulative_days(i+1); % Get x values

    y_values = weatherData.(varName)(:,7); % Get y values

    y_values2 = zeros(size(y_values)); % Initialize the array to store interpolated values

    for d=1:length(y_values)

        for j=1:length(Windspeed)-1

            if y_values(d)>=Windspeed(j) && y_values(d)<Windspeed(j+1) % Check if wind
speed is within range

y_values2(d)=(PowerGeneration(j)+(PowerGeneration(j+1)-PowerGeneration(j))*((y_values(d)-Wi
ndspeed(j))/(Windspeed(j+1)-Windspeed(j)))); % Linear interpolation

            else

                y_values2(d)=y_values2(d); % y_values2 remains unchanged

            end

        end

    end

    bar(x_values, y_values2, 'FaceColor', colors(i,:), 'EdgeColor', 'none'); % Plot as bar
graph

end

hold off
```

Results

The analysis yielded the following key results:

- **Temperature:** Plots showed significant seasonal variation in both maximum and minimum temperatures, with warmer temperatures in the summer months (Dec-Feb) and cooler temperatures in winter (Jun-Aug).

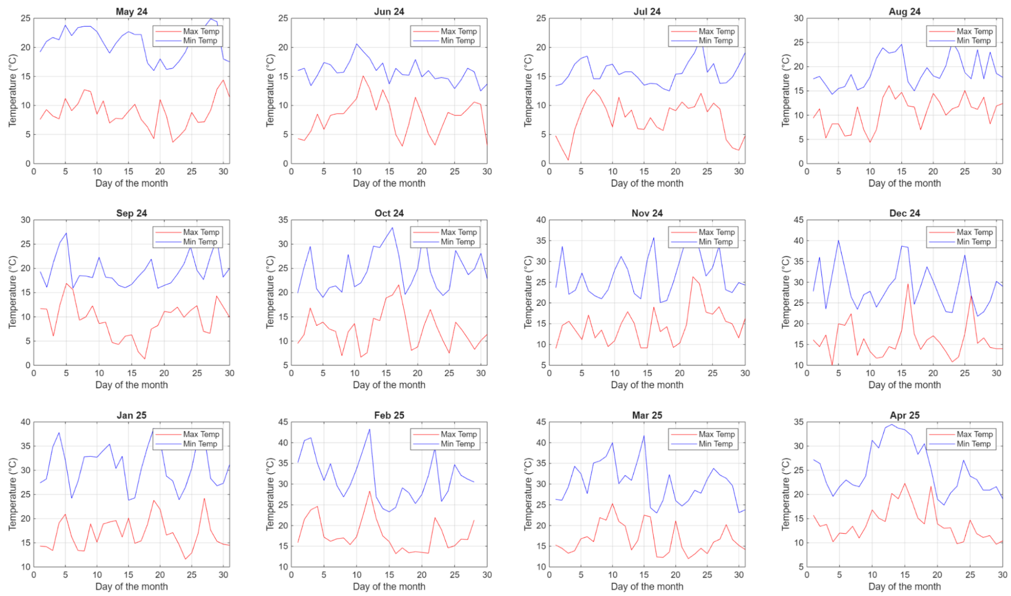

Figure 2. Monthly plots of minimum & maximum temperature

The number of comfortable days varied throughout the year, with some months experiencing a higher frequency of days within the $10°C$ to $30°C$ range than others. The specific count of comfortable days for each month were calculated, displayed and plotted.

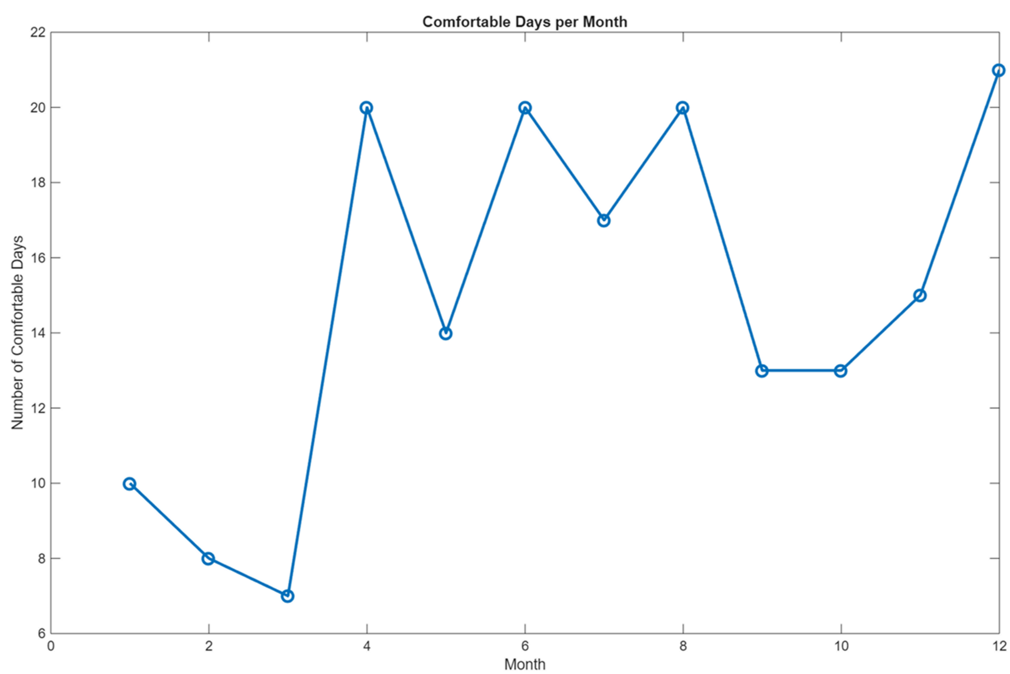

Figure 3. Plot of comfortable temperatures per month.

- **Rainfall:** The bar chart of daily rainfall showed that rainfall events occurred throughout the year, but with varying intensity and frequency across different months. The total annual rainfall was calculated to be 294.2 mm.

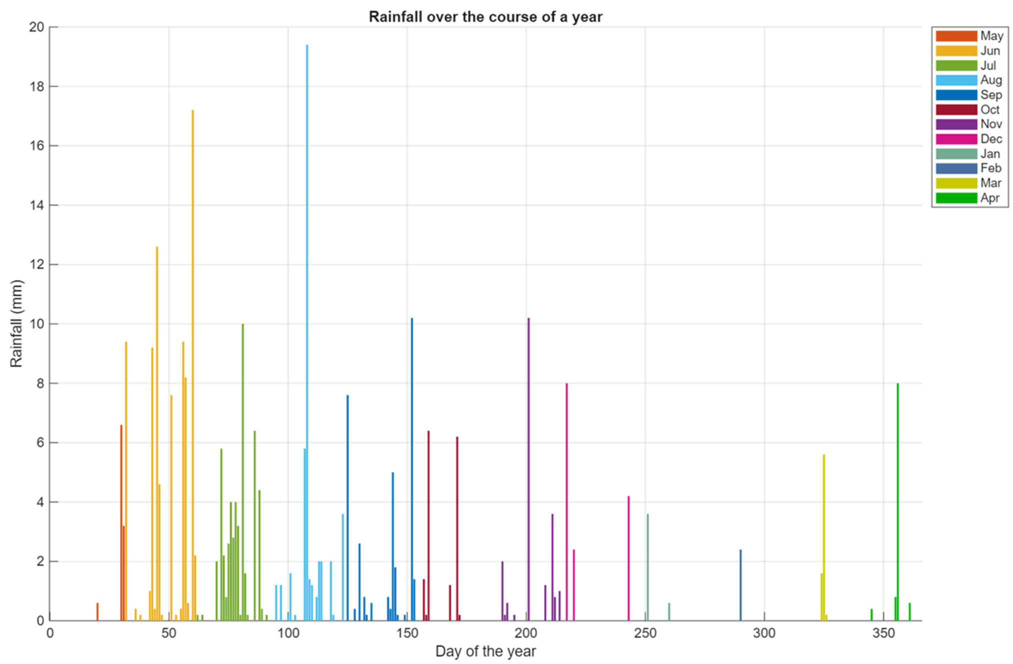

Figure 4. Bar chart of annual rain fall per day.

The rainfall statistics indicated the total number of days without rain, with normal rain, and with heavy rain over the 12-month period, with the pie chart visually summarizing the distribution of types of days.

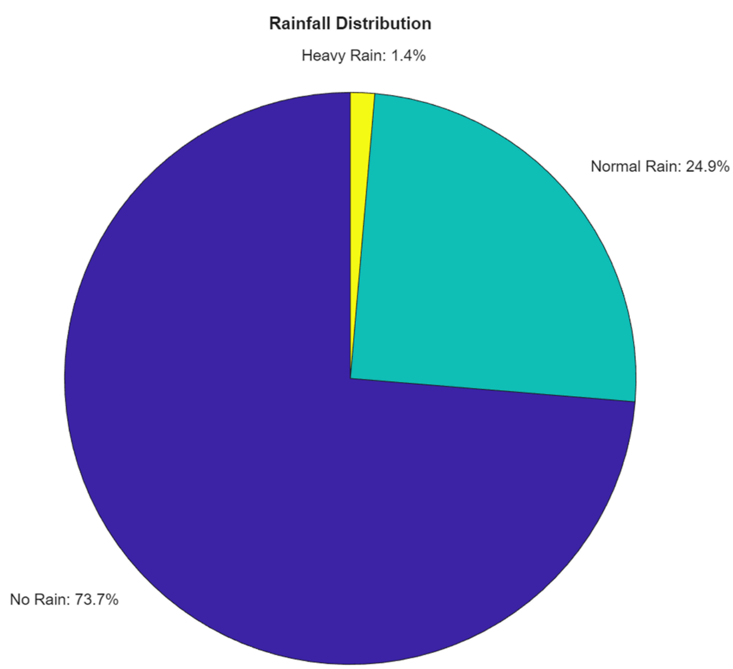

Figure 5. Pie chart of distribution of rain

- Based on the assumed roof area, the total potential annual rainwater volume was estimated to be $25.8602\ m^3$, equivalent to $25860.2\ L$. This translated to a potential annual cost savings of $\$58.2113$ based on the cost per KL of $\$2.251$[2].
- **Wind Speed:** The plot of daily wind speed showed fluctuations throughout the year, with periods of higher and lower wind activity, largely following no particular pattern. The average maximum wind speed was $26.4384\ km/h$.

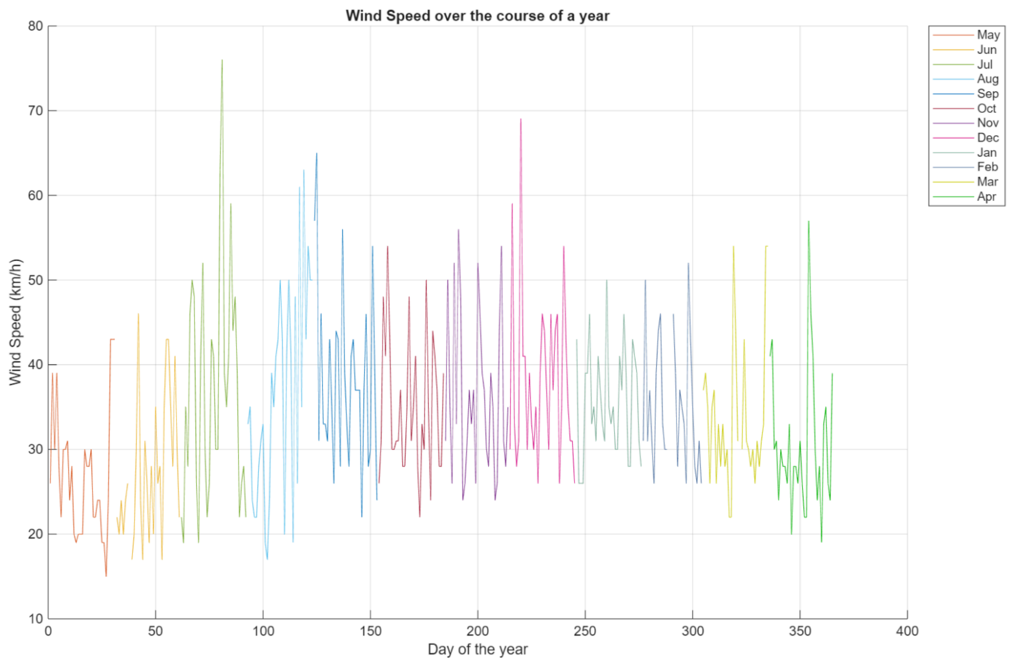

Figure 6. Annual plot of daily wind speeds.

- **Power Generation per Day:** For the model of turbine, the average power generation per day was, $0.55399\ kW$. The bar chart below plots the maximum wind speed against the power generation to wind speed array. Each bar represents the instantaneous power generated for the maximum wind speeds

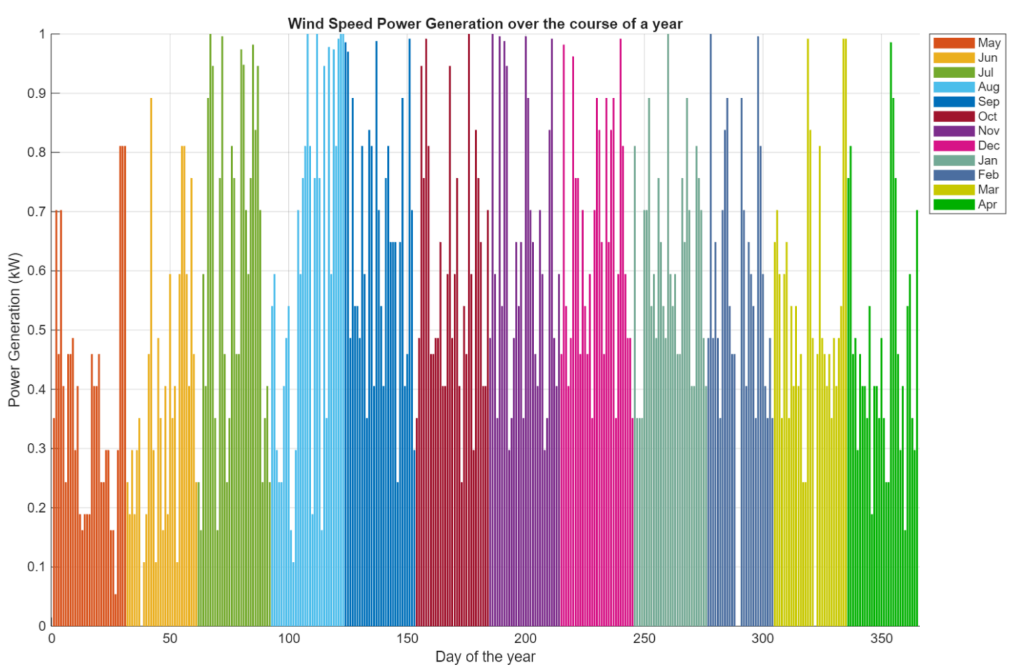

Figure 7. Annual plot of daily power generation capabilities.

Discussion of Results and Observations

The analysis of the Adelaide weather data from May 2024 to April 2025 provided valuable insights into the local climate. This analysis is particularly relevant in the context of the continuous alteration of environmental conditions on Earth attributed to climate change, as highlighted in the project's overview. Understanding local weather patterns is vital for investigating the effects of climate change and assessing the feasibility of environmentally sustainable practices, a key objective commissioned by the Bureau of Meteorology (BOM)[1].

The temperature plots clearly illustrated the distinct seasonal cycle, typical for a temperate climate like Adelaide's. However, global climate change is projected to cause alterations in temperature, potentially leading to hotter summers and colder winters. The analysis revealed that there were maximum temperatures reaching around $42°C$ and minimum temperatures dropping to around near freezing at $0.6°C$ during the study period. The calculation of "comfortable" days based on the given temperature range (min>10, max<30) showed that there were 178 comfortable days over the year. This provides a baseline against which future temperature shifts can be measured. Understanding these patterns is useful for planning outdoor activities and assessing future energy requirements for heating and cooling, especially as temperature extremes may become more frequent due to climate change. Months with a higher count of comfortable days, such as spring months with a total of 51 days, suggest periods where less artificial climate control might be needed.

The rainfall analysis highlighted the variability of precipitation throughout the year, with differing intensity and frequency across months. Climate change is expected to influence storm patterns and precipitation levels. The analysis showed that rainfall events occurred on 96 days out of the year. The total annual rainfall recorded was $294.2mm$. The breakdown of rainfall days into categories showed 73.7% with no rain, 24.9% with normal rain$(0 - 10mm)$, and 1.4% with heavy rain$(> 10mm)$. The calculation of potential rainwater harvesting volume based on an assumed roof area of $87.9m^2$ and the total rainfall demonstrated a tangible benefit of collecting rainwater, with an estimated $25.8602\, m^3$ $(25,8602L)$ potentially collectable annually. This practice represents a significant potential for reducing reliance on mains water and achieving cost savings, estimated at $\$58.2113$ based on the cost per kiloliter of $\$2.251$[2]. This is a key environmentally sustainable practice relevant to adapting to potential changes in water availability due to climate change.

The wind speed data showed that wind conditions are not constant and vary throughout the year. The analysis indicated maximum daily wind speeds ranged from approximately $15\ km/h$ to $81\ km/h$. The theoretical potential for harnessing wind energy, illustrated by the simplified power curve used, is relevant to the broader effort to generate electricity through sustainable methods and augment the green rating of properties. Graphing the relation of the maximum wind speed to the given power curve as a bar chart depicts that most days will have some power generation, with an average of $0.55399\ kW$ across the whole year. Transitioning to renewable energy sources like wind power is crucial for significantly diminishing the associated carbon footprint of households and mitigating or even curtailing the effects of climate change. While the actual power generated depends on factors like wind speed frequency and duration (e.g., wind speeds consistently between 13 to $100\ km/h$ are needed for power generation according to the model), this analysis demonstrates the potential for wind energy capture as part of a strategy to address climate change.

Overall, the analysis of Adelaide's climate data for this 12-month period provides valuable local context within the global challenge of climate change. The observed temperature, rainfall, and wind patterns, along with the exploration of rainwater harvesting and wind power, support the understanding and assessment of environmentally sustainable practices that can help mitigate or adapt to the effects of a changing climate. The specific data gathered on power generation through wind turbines and rain harvesting offers concrete information for local planning and action in response to climate change impacts.

Difficulties and Sources of Error

Several difficulties and potential sources of error were identified during this project:

- **Data Availability and Quality:** While the BoM is a reliable source, the analysis is limited to the specific 12-month period available. Future climate patterns may differ. There is also the potential for minor errors or missing data points within the raw CSV files, although none were overtly apparent in this dataset.
- **Assumptions in Calculations:** The rainwater harvesting calculation relies on an assumed total roof area and a constant cost of mains water. The actual roof area of a specific property may differ, and water tariffs can change. Furthermore, this calculation assumes 100% capture of all rainfall, which is not achievable in reality due to evaporation, runoff, and system inefficiencies.
- **Simplified Power Generation Model:** The wind power curve used a highly simplified power curve[3] with only a few data points and employed linear interpolation. Real-world wind turbines have more complex power curves, and factors like turbine size, height, location, and wind turbulence significantly impact actual power output. Linear interpolation provides only a basic estimate and may not accurately reflect performance between the defined points.
- **Generalization:** The analysis is based on data from a single location (Adelaide). Microclimates within the region could experience different weather patterns.

Conclusion

In conclusion, this project successfully analyzed 12 months of Adelaide weather data (May 2024–April 2025) to understand key climatic variables and their potential applications. The analysis revealed distinct seasonal temperature cycles, quantifiable rainfall patterns with significant potential for domestic harvesting and associated cost savings, and variable wind conditions that theoretically could support small-scale power generation. While the analysis involved certain assumptions and simplifications, particularly in the application sections (rainwater harvesting and wind power), it met the objective of extracting insights from the data and exploring these potential uses. The findings suggest that Adelaide's climate during this period was generally conducive to outdoor comfort for a significant portion of the year, offered a valuable opportunity for reducing water consumption through harvesting, and presented some theoretical potential for wind energy capture, subject to further detailed investigation and appropriate technology. With the data and technology in mind they can be applied such that climate change can be combated; creating a green energy, and harvesting rainfall for households, as well as increasing general efficiency and insulation are all great measures that also provide monetary value to the household.

References

1. “South Australia - Daily Weather Observations,” *Bom.gov.au*, 2023. http://www.bom.gov.au/climate/dwo/IDCJDW0500.shtml
2. D. of W. SA Water, “Residential water prices,” *www.sawater.com.au*, 2024. https://www.sawater.com.au/my-account/water-and-sewerage-prices/water-prices/residential-water-prices
3. Z. Wang, X. Wang, and W. Liu, “Genetic least square estimation approach to wind power curve modelling and wind power prediction,” *Scientific Reports*, vol. 13, no. 1, Jun. 2023, doi: https://doi.org/10.1038/s41598-023-36458-w.