MINI PROJECT ON

“MICROCLIMATE ANALYSIS FOR LIGHTWEIGHT SHADING

USING POSTGRESQL – TIMESCALE DB”

Submitted

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requirements for The award of the

degree of

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In

COMPUTER SCIENCE & ENGINEERING

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CERTIFICATE

This is to certify that the Project Report entitled **"MICROCLIMATE ANALYSIS FOR LIGHTWEIGHT SHADING USING POSTGRESQL – TIMESCALEDB"** that is being submitted by **P.VINEETHA (21U51A0584) , Ch. PRANATHI (22U55A0508) , NAWAAZ BIN MOHSIN (21U51A0574) , SAMEER AHMED (22U55A052)** in partial fulfillment for the award of B.Tech degree in Computer Science and Engineering to the DRK COLLEGE OF ENGINEERING AND TECHNOLOGY Affiliated to JNTU HYDERABAD, is a record of bonafied work carried out by them under the supervision of faculty member of CSE Department.

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DECLARATION

I hereby declare that the Mini PROJECT entitled **"MICROCLIMATE ANALYSIS FOR LIGHTWEIGHT SHADING USING POSTGRESQL - TIMESCALEDB"** submitted for the **DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**. This dissertation is our original work and the PROJECT has not formed the basis for the award of any degree, associate-ship, and fellowship, or any other similar titles, and no part of it has been published or sent for publication at the time of submission.

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Student name

Dedicated to my beloved

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ABSTRACT

Microclimate Analysis for Lightweight Shading using PostgreSQL - Timescale DB , focuses on analyzing climate data to determine optimal shading strategies for urban spaces. Climate datasets containing temperature, humidity, wind speed, and rainfall were sourced from the NASA POWER Data Access Viewer and organized into hourly, daily, and monthly datasets.

Lightweight shading structures help block direct sunlight, reducing heat absorption in urban areas. This is especially beneficial in regions experiencing high temperature peaks during the day.By providing shade, these structures lower surface and air temperatures, creating more comfortable outdoor environments for pedestrians and reducing heat stress. Shading reduces the cooling load on nearby buildings by minimizing heat gain, leading to lower energy consumption for air conditioning. Shading can create favorable microclimatic conditions for plants by controlling excessive sunlight and heat exposure, supporting urban greening efforts.

The data was stored and analyzed using PostgreSQL - Timescale DB , a powerful time-series database optimized for large datasets. SQL queries were used to perform time-series analysis, including data aggregation, filtering, and trend identification. Through this analysis, critical insights into temperature variations and climate behavior were extracted, which can assist in designing efficient shading strategies for sustainable urban development. The project emphasizes the importance of data normalization and efficient query optimization for handling large-scale climate datasets. The results demonstrated how PostgreSQL – Timescale DB can be effectively used to manage and analyze climate data, providing valuable insights for environmental planning and decision-making.

KEYWORDS:

Microclimate
Lightweight Shading
Urban Sustainability
Temperature
Solar Radiation
Humidity
Precipitation
Wind

CHAPTER 1

INTRODUCTION

1.1 Introduction

Microclimate analysis is essential for understanding localized weather patterns , especially in urban environments where climate variations impact human comfort , energy efficiency, and building performance.

This project focuses on using PostgreSQL – Timescale DB for efficient handling of large climate datasets. It aims to identify critical climate patterns that can help optimize lightweight shading strategies for improved0 urban sustainability.

Urban area often face increased temperatures due to heat islands, impacting public health and comfort. Lightweight shading can mitigate these effects by reducing exposure to direct sunlight, especially in pedestrian areas.

1.2 Objectives

- The primary objective is 'To analyze the microclimate impacts of lightweight shading in urban environments using SQL – based analysis, without relying on precision location data'.
- Identifying temperature, solar radiation, humidity, and wind patterns over different time intervals.
- Analyzing microclimate data using PostgreSQL – Timescale DB.
- Using SQL queries for efficient time – series data analysis.
- Recommending lightweight shading strategies based on climate behavior.
- To leverage PostgreSQL-Timescale DB for storing and analyzing large-scale time-series climate datasets efficiently.
- To explore how lightweight shading can reduce cooling energy demands in urban areas.
- To design a normalized database schema for efficient data querying and analysis.
- To identify seasonal trends and their influence on shading effectiveness.

1.3 Scope of the project

- Climate data analysis focused on one specific location using hourly, daily, and monthly datasets.
- Analyzing time – series data using a structured database approach.
- Excluding region data and weather station data to focus purely on climate metrics.
- The project analyzes key climate parameters such as temperature, humidity, wind speed, and rainfall to design shading strategies.
- Demonstrates the capabilities of PostgreSQL-Timescale DB for efficient time-series data storage and querying.
- Focuses on mitigating heat stress, managing rainfall impacts, and ensuring shading durability against wind.
- Contributes to urban heat island mitigation by reducing surface and air temperatures through shading.

1.4 Literature Review

The reviewed research emphasizes the importance of microclimate analysis in urban design and its application to lightweight shading and vertical greenery systems (VGSs). Studies highlight how urban heat islands (UHIs) and intra-urban heat islands (IUHIs) significantly affect thermal comfort and energy consumption in cities. Lightweight shading structures, such as sails and canopies, have been validated through tools like Ladybug Tools (LBT) for their ability to reduce surface and air temperatures[1]. These tools integrate microclimate simulations, enabling urban designers to optimize shading strategies by accounting for factors like material properties, shading height, and ground reflectivity[2].

Vertical Greenery Systems (VGSs) have also been extensively studied for their ability to mitigate microclimate impacts, particularly in urban street canyons. Research demonstrates that increasing greenery coverage ratios (GCRs) leads to significant reductions in wind velocity, surface temperatures, and net radiation, improving thermal conditions in dense urban environments. For example, a 100% GCR can reduce air temperatures by up to 2.5°C and surface temperatures by up to 15.7°C, proving the effectiveness of vegetation in enhancing urban microclimates[5].

Other studies explore the transition from broader UHIs to localized IUHIs, emphasizing the role of urban fabric and compact city designs in shaping microclimates. Data-driven approaches, like parametric urban design, integrate microclimate considerations with energy efficiency, allowing for optimized shading solutions tailored to specific urban contexts. Research also shows that lightweight shading structures not only reduce solar heat gain but also lower cooling energy demand, contributing to sustainable urban development[3]. Also emphasize the critical role of urban microclimates in influencing building energy performance and the importance of urban morphology in shaping these microclimates. Urban heat islands (UHIs), solar radiation, wind patterns, and humidity significantly impact the thermal performance of buildings, highlighting the need to integrate microclimate considerations into urban planning and building design. Strategies such as optimizing building orientation, implementing shading devices, and integrating greenery are identified as effective measures to mitigate adverse microclimate effects. Additionally, urban morphology, including factors like building density, height-to-width ratios of street canyons, and green spaces, plays a vital role in determining air temperature, wind flow, and solar exposure at the pedestrian level[4]. Both studies advocate for a holistic urban planning approach that incorporates microclimate considerations to enhance thermal comfort, promote energy efficiency, and create sustainable urban environments.

Overall, the literature underscores the significance of integrating microclimate analysis into urban planning to create adaptive and resilient solutions. Lightweight shading and VGSs emerge as pivotal strategies for mitigating urban heat, improving thermal comfort, and promoting energy efficiency, making them essential components of sustainable urban environments[6].

1.5 Motivation

- Rising urban temperatures due to climate change and infrastructure density.
- Urban areas face significant challenges due to the Urban Heat Island (UHI) effect, where built-up environments experience higher temperatures compared to surrounding rural areas. This project aims to mitigate these effects by providing effective shading strategies.
- In densely populated urban areas, thermal comfort is a critical factor for outdoor spaces. Lightweight shading structures can help reduce heat exposure and create more livable environments for pedestrians.
- There is a growing need for sustainable and eco-friendly solutions in urban planning. Lightweight shading not only reduces energy consumption but also supports sustainability goals by minimizing environmental impact.
- Climate data is a valuable resource for urban planners, but it requires effective analysis to extract meaningful insights. This project emphasizes the importance of data-driven decision-making for designing adaptable shading solutions.
- Shading is a cost effective, sustainable method to manage urban heat.
- Using SQL to analyze weather data can guide urban planners in designing effective shading strategies, even with generalized data.

1.6 Issues Identified

- Temperature Fluctuations:

  Rapid temperature variations can affect the effectiveness of shading structures and lightweight shading may not provide sufficient heat reduction during extreme temperature spikes.

- Wind Influences:

  Microclimates with high wind speeds can destabilize lightweight shading structures. Wind direction and intensity might reduce shading efficiency or even damage structures.

- Humidity and Moisture retention:

  High humidity levels can lead to condensation under shading materials, reducing comfort. Moisture retention in certain shading materials can affect durability and thermal insulation.

- Rainfall Management:

  Heavy rainfall in microclimates may lead to water pooling under shading structures and insufficient drainage design can reduce the lifespan of shading elements.

- Inconsistent sun exposure, material suitability and durability, Limited coverage and flexibility.
- Urban heat island effect.

CHAPTER 2
DATA COLLECTION AND PREPROCESSING

2.1 Data Collection

The datasets were obtained from the **NASA POWER Data Access Viewer**, which provides reliable climate data for research purposes. The datasets we can choose our own by locating the regions, we get all climatic conditions of that specific region. This website is very useful for the climatic analysis.

2.2 Datasets Used

1. Hour data: The climate data collected for every hour. Based on this data, we can identify the peak heat hours.
2. Daily data: Aggregated climate data for each day to identify the peak heat days per daily.
3. Monthly data: It's a long-term climate trends for monthly analysis.

2.3 Data cleaning and preprocessing

– The NASA POWER Data Access Viewer was used to extract climate data for this project, consisting of hourly, daily, and monthly datasets. Before analysis, the data underwent cleaning and preprocessing to ensure its quality, consistency, and usability.

– For hourly data, missing values were filled using linear interpolation to maintain temporal continuity.

– For daily and monthly data, averages from nearby days or months were used to fill gaps where possible.

– Rows with extensive missing data across multiple metrics were removed.

– The cleaned and standardized datasets ensured high-quality inputs for analysis.

– Missing data and outliers were handled, preserving the integrity of the climate trends.

– The consistent structure across datasets enabled seamless querying and visualization in Power BI.

CHAPTER 3
DATABASE SETUP

3.1 Database Schema Explanation

- Using PostgreSQL with an extension of Timescale DB (A built-in platform of PostgreSQL).
- Created tables for key climate variables (e.g., temperature, solar radiation etc.) and storing the data by time and date to analyze patterns across peak sunlight hours.

1. Hour data Table: (day, hour, temperature, all sky radiation, clear sky, radiation, wind direction).
2. Daily data Table: (year, month, day, temperature, all sky radiation, clear, sky radiation, relative humidity, wind speed, wind direction)
3. Monthly data Table: (year, month, temperature, all sky radiation, clear sky radiation, relative humidity, wind speed, wind Direction, precipitation)

3.2 Normalization levels

- **1NF:** Each column contains atomic values (seperated columns for temperature and Humidity).

- **2NF:** All non –key columns fully depend on the primary key (hour, month).

- **3NF:** No transitive dependencies exist, as each dataset directly relates to the climate metrics.

3.3 Query Analysis

SQL queries, to identify peak temperature times and intensity of solar radiation. The queries executed for each analysis is:

- Peak heat hours of heat
- Monthly and daily temperature trends
- Data aggregation and statistical analysis
- Correlation analysis of temperature and solar radiation

3.4 Source Code

```
###Creation_of_hour_table

create table hour_data(
Year int,
Month int,
Day int,
Hour int,
T2M float,
ALLSKY_SFC_SW_DWN float,
CLRSKY_SFC_SW_DWN float,
RH2M float,
WS10M float,
WD10M float)

select * from hour_data;
select * from hour_data;

###Peak heat analysis

select hour, avg(t2m) as
avg_temperature
from hour_data
where hour between 12 and 16
group by hour;

###Solar radiation

select year,month,day,hour,
ALLSKY_SFC_SW_DWN,
CLRSKY_SFC_SW_DWN
from hour_data
where hour between 12 and 16
order by year,month,day,hour;

select year,month, day,
avg(allsky_sfc_sw_dwn) as
avg_solar_radiation
from hour_data
where hour between 12 and 16
group by year,month,day
order by year,month,day;

###Wind speed patterns

select year,month,day,
max(ws10m) as max_wind_speed
from hour_data
group by year,month, day
order by year, month, day;

###Creation_of_daily_data_table

create table daily_data(
year float, month int, day int,
clrsky_sw_sfc_dwn float,
allsky_sw_sfc_dwn float,
t2m_max float, t2m_min float,
rh2m float, qv2m float,
ws10m_max float, ws10m_min float,precipitation float
)
```

```
select* from daily_data;
select* from daily_data;

### Daily Max_Min Temperatures

select  year, month, day,
t2m_max, t2m_min,
(t2m_max - t2m_min) as
temperature_range
from daily_data
order by year, month, day;

### Daily precipitation

select year, month, day,
sum(precipitation) as total_precipitation
from daily_data
group by year, month, day
order by year, month, day;

###Daily Solar radiation diff.

select year, month, day,
clrsky_sw_sfc_dwn as clearsky_radiation,
allsky_sw_sfc_dwn as allsky_radiation,
(clrsky_sw_sfc_dwn - allsky_sw_sfc_dwn) as radiation_difference
from daily_data
order by year, month, day;

select year, month, day,
t2m_max, precipitation
from daily_data
where t2m_max > 35 or
precipitation > 50
order by year, month, day;

###Creation_of_montly_data_table

create table monthly_data(
month varchar,
rh2m float, t2m_max float,
t2m_min float, ws10m_max float,
ws10m_min float, prectotcorr_sum float,
allsky_sw_sfc_dwn float,
clrsky_sw_sfc_dwn float)
select * from monthly_data;

select* from daily_data;

###Monthly avg_temperature

select year, month,
avg((t2m_max + t2m_min)/2) as
avg_temperature
from daily_data
group by year, month
order by year, month;

###Total monthly precipitation

select year, month,
sum(precipitation) as
total_monthly_precipitation
```

```
from daily_data
group by year, month
order by year, month;

###Seasonal patterns

select month,avg(t2m_max) as
avg_max_tempetrature,
avg(allsky_sw_sfc_dwn) as
avg_radiation
from monthly_data
where month in ('MAR', 'APR', 'MAY')
group by month;

 select * from hour_data;
 select* from daily_data;
 select* from monthly_data;

 ###Creation_of_data_view

create view combined_data as
select year, month, day,
'hourly' as source,
 t2m as temperature,
 allsky_sfc_sw_dwn as
 solar_radiation
 from hour_data
 where hour between 12 and 16

 union all

 select year,month,day,
 'daily' as source,
  null as temperature,
  allsky_sw_sfc_dwn as
  solar_radiation
  from daily_data

  union all

  select null as month,null as day,
  null as day,
  'monthly' as source,
  t2m_max as temperature,
  allsky_sw_sfc_dwn as
  solar_radiation
  from monthly_data;

  select * from combined_data;
```

3.5 ER Diagram

- One – to - many relationships align with the structure of data.

CHAPTER 4

VISUALIZATIONS

4.1 Results and Insights

- Temperature Analysis, analyzed the max – min temperature across months, seasons and specific time between 12pm - 4 pm. It also shows the count of temperature at minimum and maximum across specific hours as shown below:

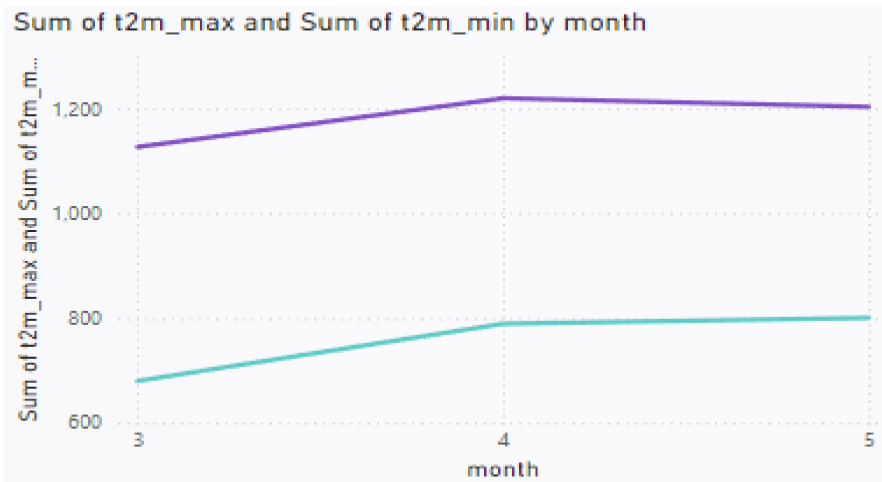

Fig. (1): min-max temperature

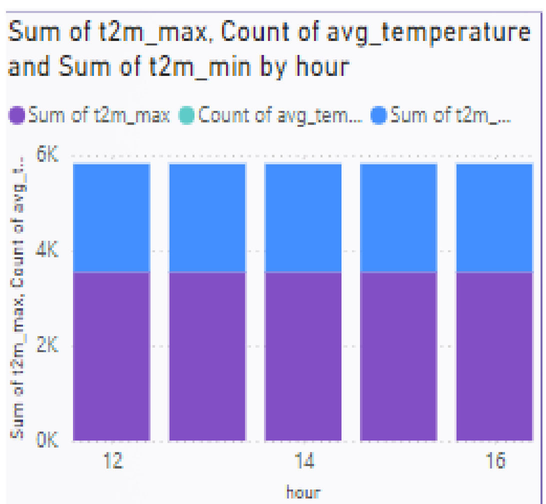

Fig. (2): count of min-max & avg temperature

- Solar radiation Analysis, assessed the solar radiation levels during key factors determine potential for lightweight shading. The radiation difference and sum of temperature and two types of solar radiation shown below:

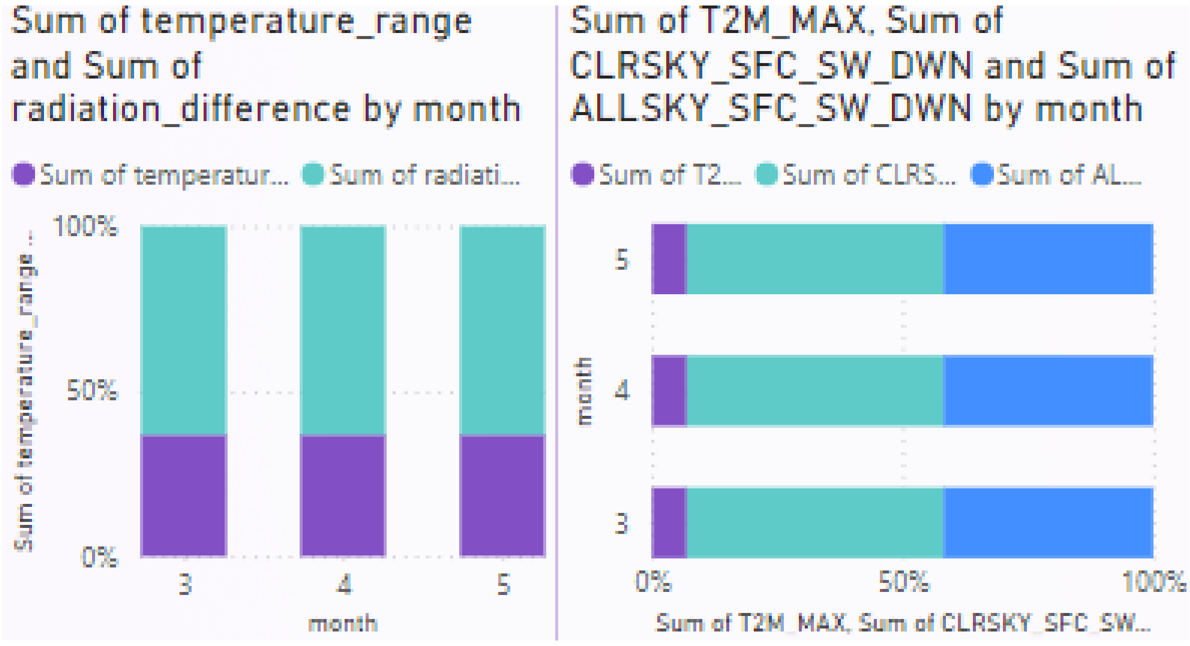

Fig. (3): solar radiation and sum of temp-range, radiation difference

- Seasonal Microclimate Patterns using humidity, precipitation across specific months.

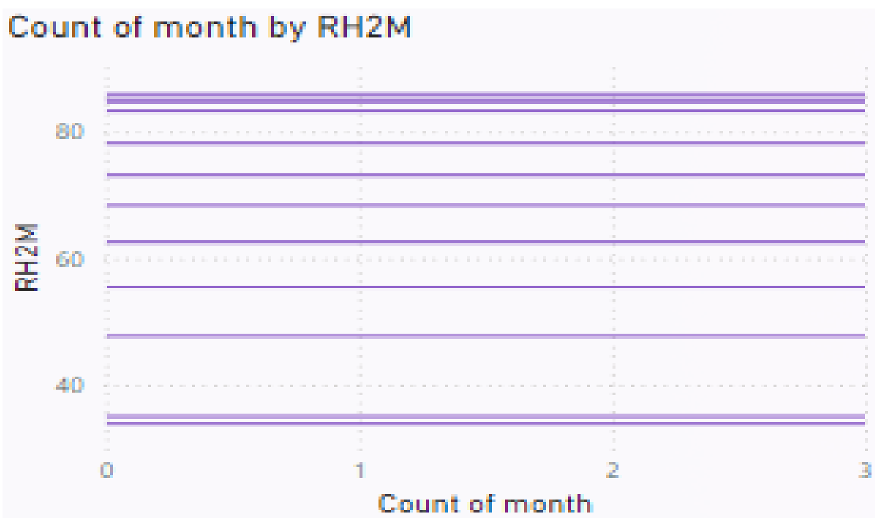

Fig. (4): Relative humidity

- Wind speed and direction analysis, evaluating wind speed and direction for optimal shading or ventilation design.

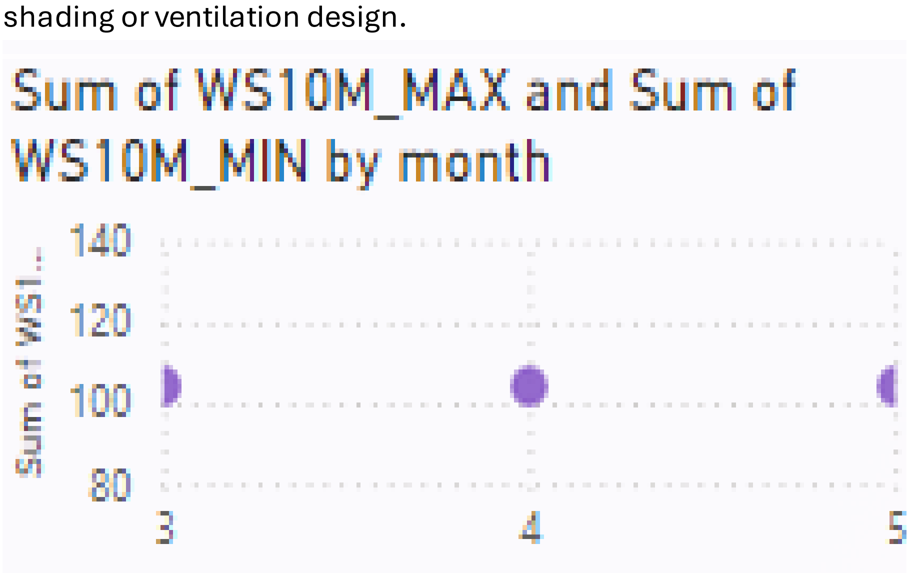

Fig. (5): Wind speed at 10 meters

- Humidity and Precipitation trends, the effect of humidity and precipitation across specific months (March, April, May), as shown as Fig. (6)...

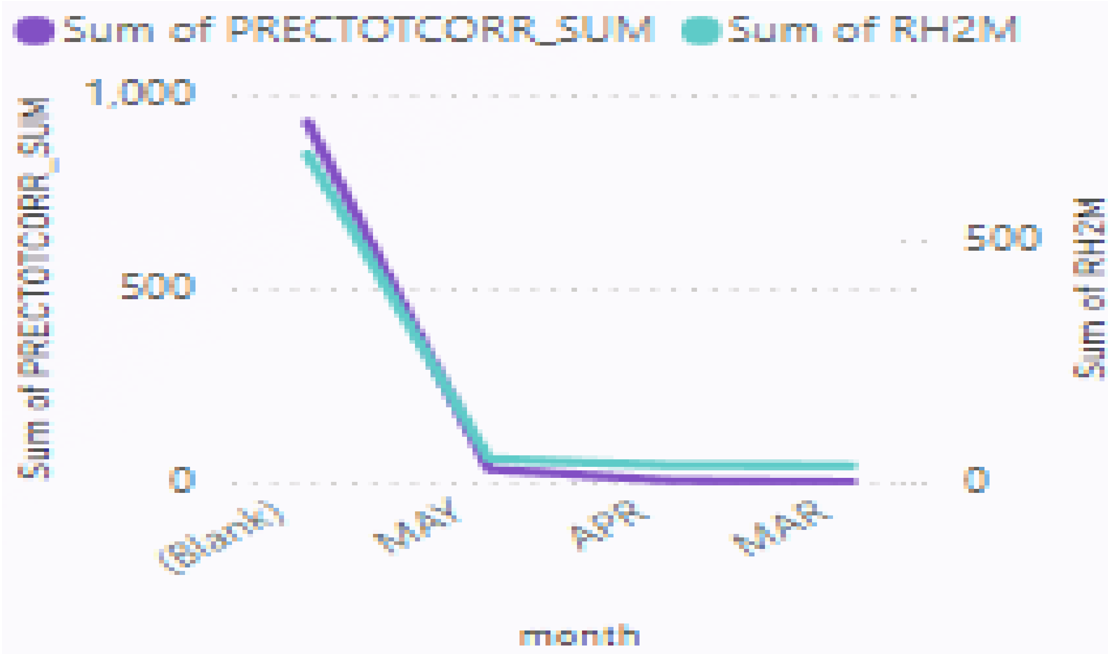

Fig. (6): Precipitation and Humidity

- The two types of radiation were occupied (in %) across specific hours is shown below:

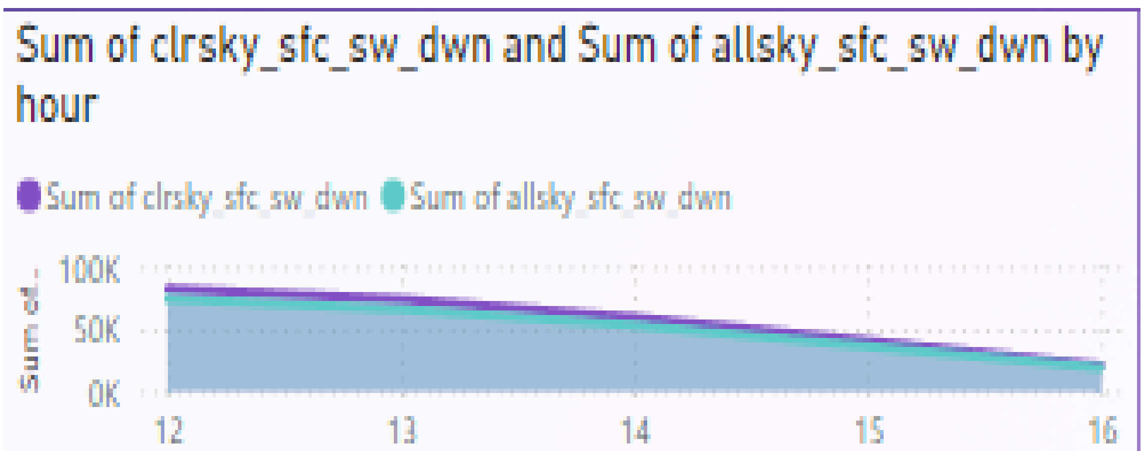

Fig. (7): Solar radiation by hour

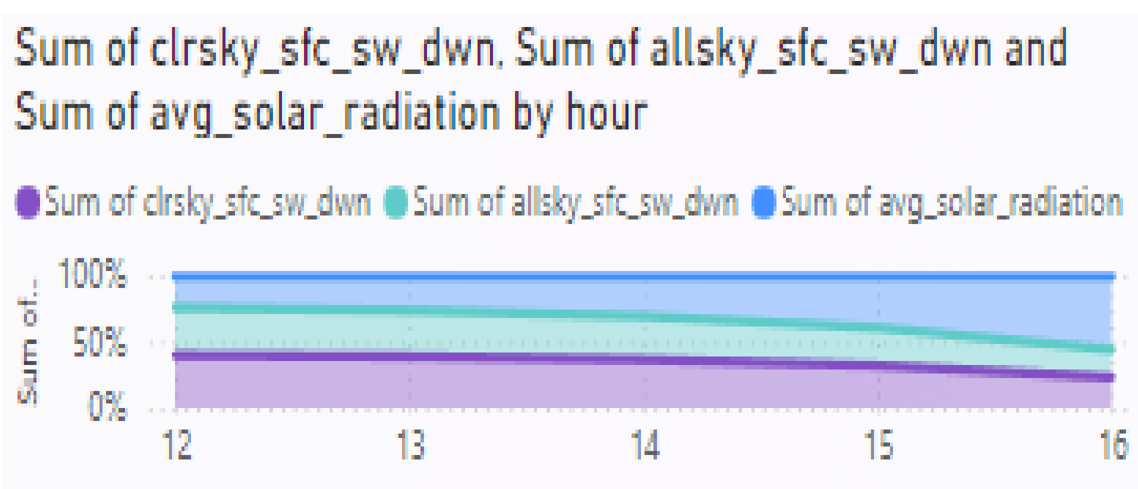

Fig. (8): Avg- solar radiation by hour

Here, the overall visualizations show the intensity of solar radiation in the two types namely all sky radiation and clear sky radiation. Clearly, can analyze how the intensity of solar radiation is covered (in %). Shown in figures 7 and 8.

The maximum and minimum temperature trends and count across the specific peak heat months and specific time between 12 pm – 4 pm, shown in figures 1 and 2. It also specifies the changes of temperature at mid – noon and at the sunset time.

The solar radiation analysis shows that the high intensity of radiation across months, it also specifies that the variations in intensity of solar radiation as shown in figure 3. The radiation impact on shading by hours at the specific time between 12 pm – 4 pm as shown in above figures 7 and 8.

Relative humidity and precipitation show that the intensity of rainfall trends across specific months (March, April, May), shown above figure 6. The maximum wind speed and minimum wind speed across specific months shown above figure 5.

4.2 Types of Visualizations Created

- **Line graphs:** The line graph shown below is the min – max temperature trends and relative humidity, precipitation (Rainfall intensity) across specific months and hours as shown above figures 1.1, and 5.
- **Bar charts:** The bar charts are of different types were used for visualization i.e., Stacked bar chart and Stacked column chart.

  This stacked bar chart and column chart shows the correlation between the temperature and solar radiation across months and hours. It also shows the comparison between the key factors like temperature, solar radiation etc., across specific months as shown above figures are fig. (1.2) and fig. (2).
- **Area charts:** These area chart shows that how much percentage, the Solar Radiation intensity across months and hours as shown above figures are fig. (6.1) and fig. (6.2).
- **Scatter plot:** This plot shows the min – max of wind speed, shown above figure is fig. (4).

4.3 Tools used for Visualization

Power BI tool which was powerful visualization tool, used for creating interactive visualizations and dashboards for climate data analysis.

4.4 Insights from visualizations

1. From hour data, the visualization created as line graphs which highlights the temperature fluctuations within a day, emphasizing the need for shading during peak hours.
2. Using daily data, bar charts illustrated average solar radiation and radiation differences by min – max of solar radiation. It also indicates the patterns for Shading adjustments.
3. The monthly data is used as finding the seasonal patterns across the months and it recommends the shading structures regarding to the seasonal climate changes.
4. The temperature trend analysis is ideal for implementing adaptive shading solutions where shading structures during specific seasons.
5. The higher humidity levels were recorded during rainy months, reducing the shading effectiveness due to moisture retention. The Humidity levels are low in summer season that suggesting an effective shading can reduce heat stress.
6. It is suitable for moisture – resistant shading materials, especially in high – humidity climates.
7. The precipitation shows the highest rainfall in monsoon months, the lightweight shading might need water proofing adjustments during heavy rainfall seasons. It also helps in seasonal shading planning and material selection based on rainfall seasons

CHAPTER 5

TOOLS AND TECHNOLOGIES

- **Database management –** PostgreSQL with an extension of Timescale DB:

  PostgreSQL is an open-source relational database management system (RDBMS) known for its reliability, extensibility, and performance. Used to store and manage large-scale climate datasets (hourly, daily, and monthly). Enabled the application of SQL queries for data retrieval, aggregation, and filtering. Data normalization for efficient storage. Support for indexing to optimize query performance. Robust support for handling time-series data.

  Timescale DB is a time-series extension for PostgreSQL, designed to handle large-scale time-series datasets efficiently. Simplified time-series queries such as aggregations and trend analysis.

- **Data source –** NASA POWER Data Access Viewer:

  A web-based tool provided by NASA to access climate and weather data globally. Source of hourly, daily, and monthly climate data for the analysis. Provided metrics such as temperature, humidity, solar radiation, and wind speed. Access to historical climate data. Easy data download in formats like CSV for integration into the database.

- **Programming Language** – SQL:

  SQL is the standard language for querying and managing data in relational databases like PostgreSQL. Used to perform data cleaning, transformation, and analysis. Enabled complex queries for filtering, aggregation, and trend identification.

- **Visualization tool** – Power BI:

  Power BI is a business intelligence tool used for creating interactive dashboards and data visualizations. Visualized trends in temperature, humidity, wind speed, and rainfall. Provided insights into climate patterns through line graphs, bar charts, and area charts. Data import from PostgreSQL for seamless integration. Creation of interactive visuals for analyzing climate trends. Real-time filtering and drill-down capabilities for deeper insights.

- **The characteristics of tools and technologies as follows as:**

1. **Efficiency:** Timescale DB enhanced query performance for time-series data.

2. **Scalability**: PostgreSQL supports large datasets and complex queries, making it suitable for this project.

3. **Visualization:** Power BI offered intuitive and interactive dashboards to present results effectively.

4. **Reliability:** NASA POWER Data provided trustworthy climate data for accurate analysis.

CHALLENGES FACED

1. Managing large datasets with hourly climate data.
2. Query optimization for faster results using indexing.
3. Ensuring no missing or erroneous values.

CONCLUSION

Microclimate analysis for lightweight shading using postgresql – timescale db successfully demonstrated the importance of data – driven decision – making for sustainable shading strategies. By analyzing climate datasets, insights on temperature, humidity, radiation were obtained. The visualizations provided clear interpretations of climate variations.

The findings emphasize the significance of microclimate analysis for enhancing thermal comfort and promoting energy – efficient urban planning.

FUTURE SCOPE

- Incorporation of Real – Time Climate Data for dynamic shading adjustments.
- Machine Learning Integration for predictive analysis of climate behavior.
- Expanding datasets including multiple regions for comparative analysis.
- Real – Time data analysis and automation.
- Advanced shading models that are incorporate variables such as humidity, wind flow, and adaptive shading structures for a more comprehensive microclimate model.
- Using real time APIs could allow the dynamic analysis of shading need across different seasons and conditions.
- Visualization tools could make insights from SQL analysis more accessible and applicable for urban planners.

REFERENCES

1. Data driven design for urban street shading: Validation and application of ladybug tools as a design tool for outdoor thermal comfort
   Urban Climate, July 2024,Sinéad Nicholson Marialena NikolopoulouCarlo Ratti. https://doi.org/10.1016/j.uclim.2024.102041

2. Sensitivity analysis of building material, ground material, and tree parameters in microclimate simulations.
   Urban Climate, November 2024,Anh-Vu LeOi-Man HipYing-Chieh Chan
   https://doi.org/10.1016/j.uclim.2024.102184

3. Influence of urban morphology on potential of green roofs in regulating local microclimate:A case study of Liege, Beligium
   Urabn climate , November, Mitali Yeshwanti Joshi, Auline RodlerJacques Teller
   https://doi.org/10.1016/j.uclim.2024.102144

4. From Urban heat islands to intra-urban heat islands: Role of Urban fabric in redefining microclimate of tomorrow’s compact cities.
   Energy and Buildings, 1 December 2024, V.M. Jayasooriya, M.D. Adams
   https://doi.org/10.1016/j.enbuild.2024.114900

5. Urban microclimate and energy consumption: A multi-objective parametric urban design approach for dense subtropical cities
   Frontiers of Architectural Research, June 2022, Nastaran Abdollahzadeh Nimish Biloria
   https://doi.org/10.1016/j.foar.2022.02.001

6. Influence of vertical greenery systems with different greenery coverage ratios on microclimate improvement in street canyons by scaled outdoor experiments
   Building and Environment, 1 January 2025, Xiaona Zheng Weiwen Wang Lan Pan https://doi.org/10.1016/j.buildenv.2024.112158.