RAINSENSE: A SMART ESTIMATOR FOR ROOFTOP RAINWATER HARVESTING SYSTEM

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

One of the biggest hurdles of the modern world is water shortage. Ironically enough, even regions receiving a lot of rainfall do face severe shortages because most of the water is lost to runoff. While rooftop rainwater harvesting (RRWH) is a viable means of combating this loss, its use is frequently hindered by the problem of effectively determining what can actually be harvested.

We developed RainSense, a Python tool to estimate the amount of rainwater rooftops can collect.

It takes into account roof area, type of material, and water loss in collection due to the roofing material. It operates on large datasets, associate results with a particular location, and generate simple plots. These aspects make it useful to household owners who need to conserve water as well as the government and planners who are planning city-level systems. In place of general assumptions, RainSense provides realistic estimations that render water management decisions are more dependable and user-friendly.

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CHAPTER 1

INTRODUCTION

1.1. OVERVIEW

Water scarcity is a pressing issue in many parts of India, particularly in urban and semi-urban regions where population growth, industrial expansion, and climate variability have placed immense pressure on existing water resources. Although India receives substantial rainfall annually, a large portion of it is lost as surface runoff due to inadequate collection infrastructure and poor management practices. Rooftop rainwater harvesting (RRWH) offers a practical and sustainable method to alleviate this problem by capturing and utilizing rainwater at its source.

The RainSense mini project is designed to provide a data-driven and user-friendly solution for localized rooftop rainwater harvesting analysis. It integrates historical rainfall data, geospatial mapping, and hydrological calculations to estimate the water harvesting potential of any given locality in India. For this purpose, the project uses the Kaggle dataset “Rainfall in India: Sub-division wise monthly data for 115 years (1901–2015)”, which contains long-term monthly rainfall data for various meteorological sub-divisions. Using Nominatim, a geocoding service, the system maps a user-provided locality to its corresponding sub-division in the dataset. Based on roofing material efficiency coefficients (0.85 for concrete, 0.95 for metal, and 0.80 for tile) and rooftop area, the system calculates both the potential amount of water that can be stored in rooftop tanks and the amount that can be recharged back to the ground. The results are visualized through bar charts showing monthly storage and recharge volumes along with annual rainfall trends. By combining data analysis, geospatial intelligence, and visualization, RainSense promotes sustainable water usage at the household and community level, aligning with Sustainable Development Goals 6 and 12.

1.2. PROBLEM DEFINITION

India faces a dual challenge in water management: scarcity during dry seasons and excess runoff during monsoons. Although rainwater harvesting is a proven solution, its implementation remains inconsistent and inefficient due to several reasons. Localized rainfall data is rarely used during planning, and there is a lack of accessible analytical tools to help individuals assess their harvesting potential. Traditional designs often depend on generic assumptions, leading to either under utilization or overestimation. Urban areas face rapid runoff during rainfall, which contributes to flooding, while simultaneously experiencing water shortages during summer months. Policies encourage rainwater harvesting, but citizens often lack personalized, data-backed tools to understand its practical benefits.

The RainSense project addresses these issues by developing a Python-based system that accepts user input, maps it to historical rainfall data, applies suitable roof material coefficients, and computes both storage and recharge potential. The results are displayed through simple visualizations, enabling users to make informed decisions about implementing rooftop rainwater harvesting in their localities.

1.3. LITERATURE SURVEY:

In recent years, extensive research has been carried out on rooftop rainwater harvesting, highlighting its feasibility, economic benefits, and technological advancements. Reddy and Kumar (1) studied its potential to reduce urban dependence on conventional water sources, while Sharma et al. (2) assessed RRWH systems in semi-arid regions where water scarcity is severe. Thomas and Andrews (3), along with Meena and Jain (4), focused on the role of RRWH in promoting water sustainability and supporting urban development. Patel and Sinha (6) examined its viability in residential buildings, and Chatterjee et al. (5) tested system efficiency in Eastern India. Cost–benefit analyses by Bhatia and Kumar (7) confirmed the economic feasibility of RRWH, while Singh (8) provided a detailed account of its role in water conservation. Sharma and Verma (9) studied its integration into urban water management practices.

More recent studies have incorporated advanced methods and emerging technologies. Gupta and Prasad (11) explored the integration of RRWH into climate and urban planning. Desai et al. (10) improved system designs for coastal regions. Yadav et al. (12) analyzed the use of harvested rainwater for drinking, while Choudhary and Gupta (14) evaluated potential through GIS-based mapping. Sharma and Kothari (13) combined RRWH with urban stormwater management, and Kumar et al. (15) introduced IoT-enabled RRWH systems for real-time monitoring and management. These studies emphasize the increasing relevance and versatility of RRWH in addressing urban water challenges and provide a strong foundation for the RainSense project, which integrates historical rainfall data, geo-encoding, and visualization to offer practical, location-specific insights.

CHAPTER 2

SYSTEM ANALYSIS

2.1. EXISTING SYSTEM

Traditional rainwater harvesting methods rely mostly on average rainfall estimates and manual calculations. They rarely consider regional variations or long-term data, which often leads to inaccurate assessments of storage and recharge potential. Most users do not have access to localized rainfall data or easy analytical tools, resulting in systems that are either undersized or inefficient. Visualization and geo coding are generally absent, and users often depend on broad statistics rather than precise, location-specific information. These limitations make existing systems less reliable and hinder widespread adoption.

2.2. PROPOSED SYSTEM

The RainSense system introduces a data-driven approach by combining historical rainfall data with geocoding and simple computation. Users enter their locality, which is mapped to the relevant meteorological sub-division using Nominatim. Monthly rainfall data from the Kaggle dataset is then retrieved and used to calculate rooftop water harvesting potential based on roof area and material efficiency coefficients. The system provides both storage and recharge estimates and visualizes the results using bar charts and annual rainfall graphs. By relying on accurate data and automated processing, the proposed system offers a more practical and location-specific solution.

2.3. IMPLEMENTATION ENVIROMENT

2.3.1. SOFTWARE REQUIREMENT

- Operating System: Windows and macOS
- Development Environment: Google Colab (CLI interface), Visual Studio Code (Electron-based application)
- Programming Language: Python 3.12
- Python Libraries: Pandas, NumPy, Matplotlib, Geopy (for Nominatim)

2.3.2. HARDWARE REQUIREMENT

- Processor: Minimum Intel i3 or equivalent
- Memory (RAM): Minimum 8 GB
- Hard Drive: Minimum 32 GB
- Internet Connection: Required for geolocation services and API access

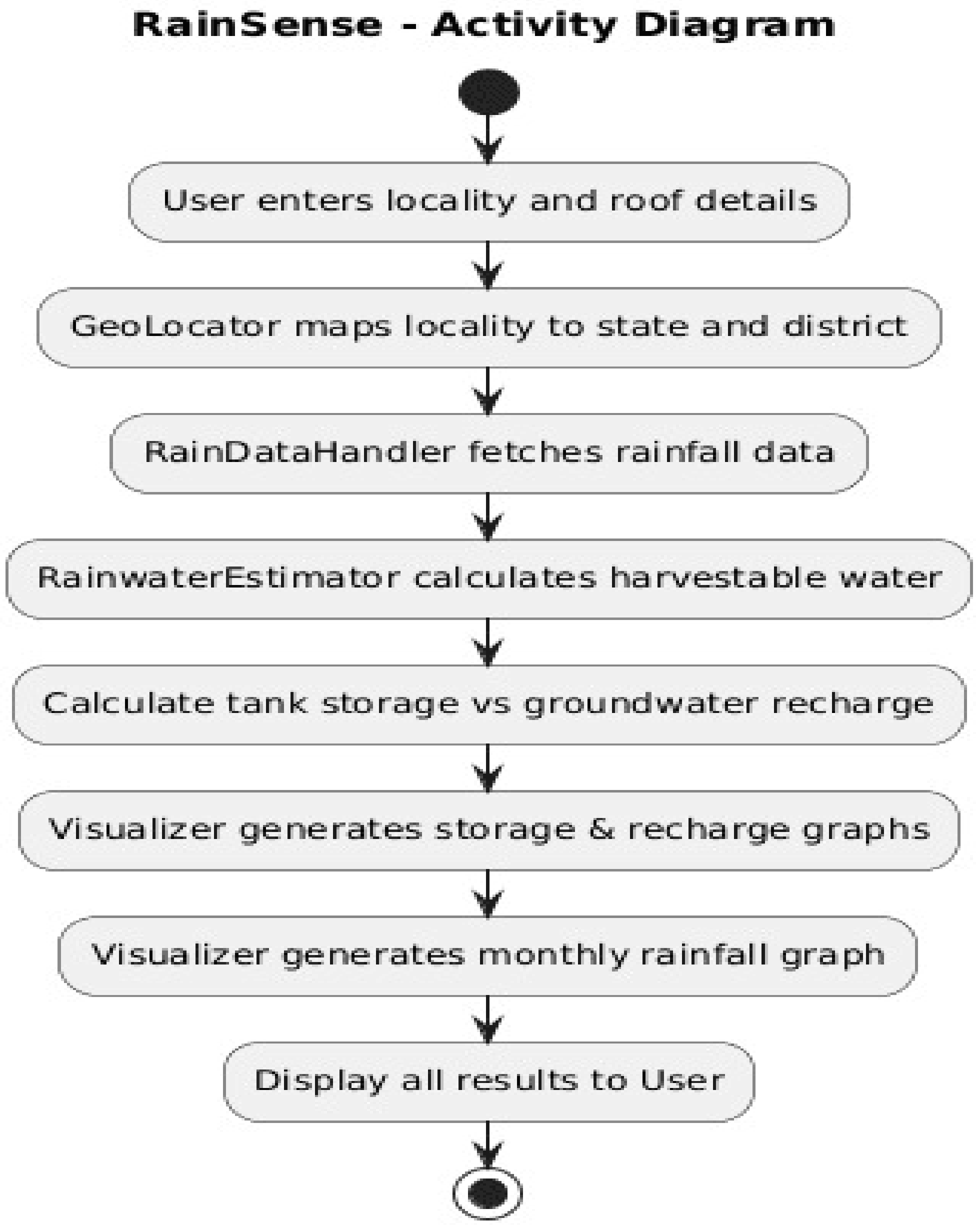
CHAPTER 3

SYSTEM DESIGN

3.1 UML DIAGRAMS

ACTIVITY DIAGRAM

Fig: 3.1.1 Activity Diagram of RainSense



The Activity Diagram provides a high-level view of the application's workflow, modeling the flow of control from one activity to the next.

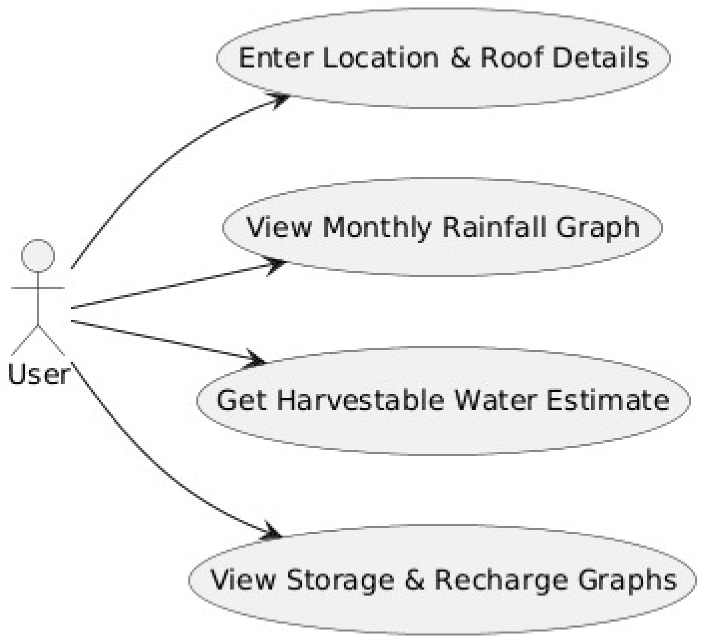
The workflow proceeds through these sequential steps:

1. The process begins when the User enters locality and roof details.
2. The GeoLocator maps the locality to a state and district.
3. The RainDataHandler fetches the corresponding rainfall data.
4. The RainwaterEstimator calculates the harvestable water, which is then analyzed for tank storage and groundwater recharge potential.
5. The Visualizer generates graphs for storage, recharge, and monthly rainfall.
6. Finally, all results are displayed to the User, and the process terminates.

USE CASE DIAGRAM

The Use Case diagram defines the system's functionality from the user's perspective. The system has one primary actor, the **User**, who can perform the following key actions:

- **Enter Location & Roof Details:** Provide the necessary input data, such as city, roof area, and material type, to initiate the estimation process.
- **Get Harvestable Water Estimate:** Trigger the core calculation to receive a quantitative estimate of the water that can be collected.
- **View Monthly Rainfall Graph:** Access a visual representation of historical rainfall patterns for the specified location.
- **View Storage & Recharge Graphs:** Analyze the final results through graphs that illustrate potential water storage and groundwater recharge.

- 

CLASS DIAGRAM

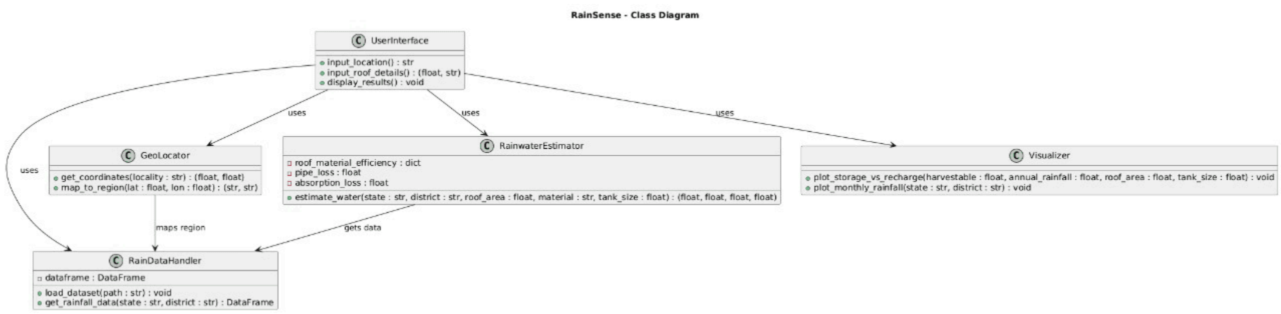
The system's static structure is defined by an object-oriented class model. This design promotes modularity by separating distinct responsibilities into different classes.

Class Descriptions:

- **UserInterface**: Manages all user interaction.
- **GeoLocator**: Handles geographical data processing.
- **RainDataHandler**: Acts as the data access layer for the rainfall dataset.
- **RainwaterEstimator**: The core calculation engine for harvesting estimations.
- **Visualizer**: Creates graphical representations of the results.

Class Relationships:

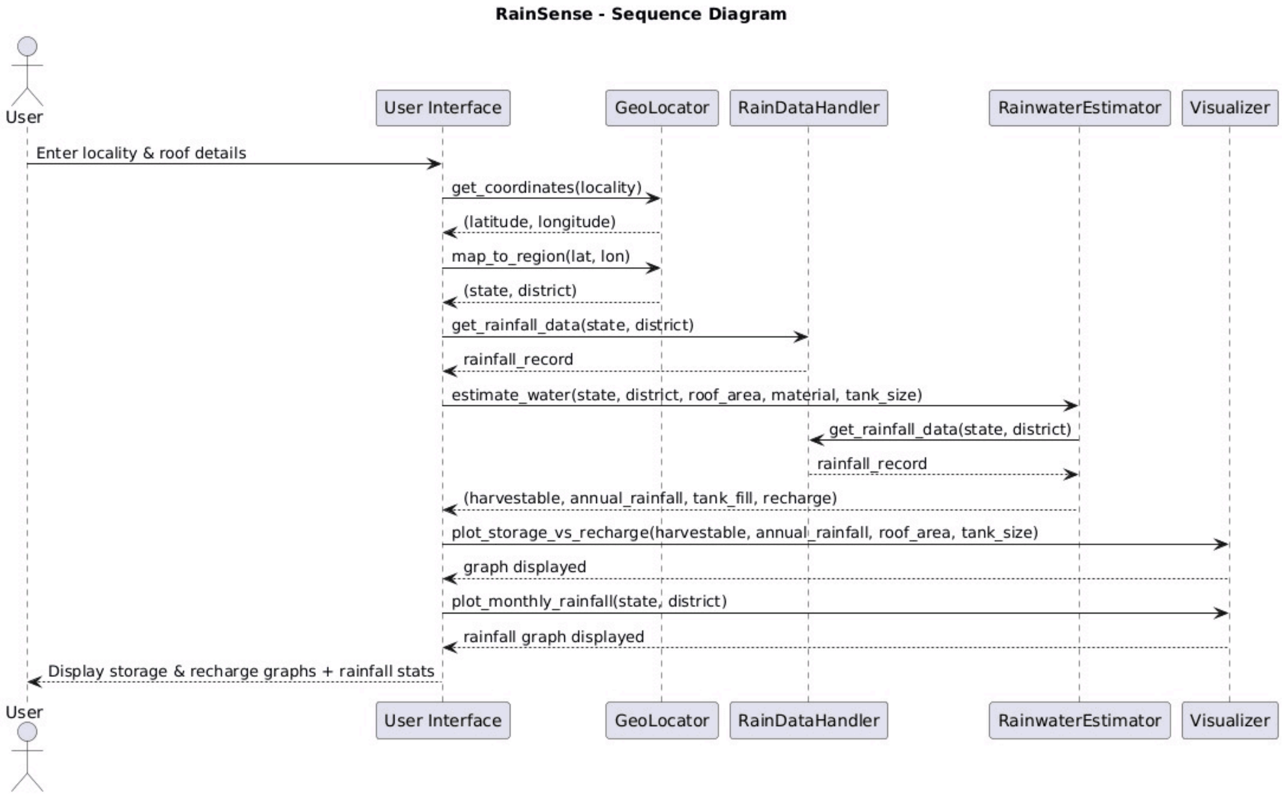
The UserInterface acts as the central controller, coordinating the workflow by calling methods on the other components. The application logic is effectively decoupled from the data source, as components depend on the RainDataHandler for data access.



SEQUENCE DIAGRAM

The Sequence Diagram shows the chronological interaction between objects to fulfill a user request.

The flow is orchestrated by the **UserInterface**. It first calls the **GeoLocator** to determine the region, then delegates the main calculation to the **RainwaterEstimator**, which fetches data via the **RainDataHandler**. Finally, the UserInterface uses the **Visualizer** to plot the results before displaying the final output to the user.



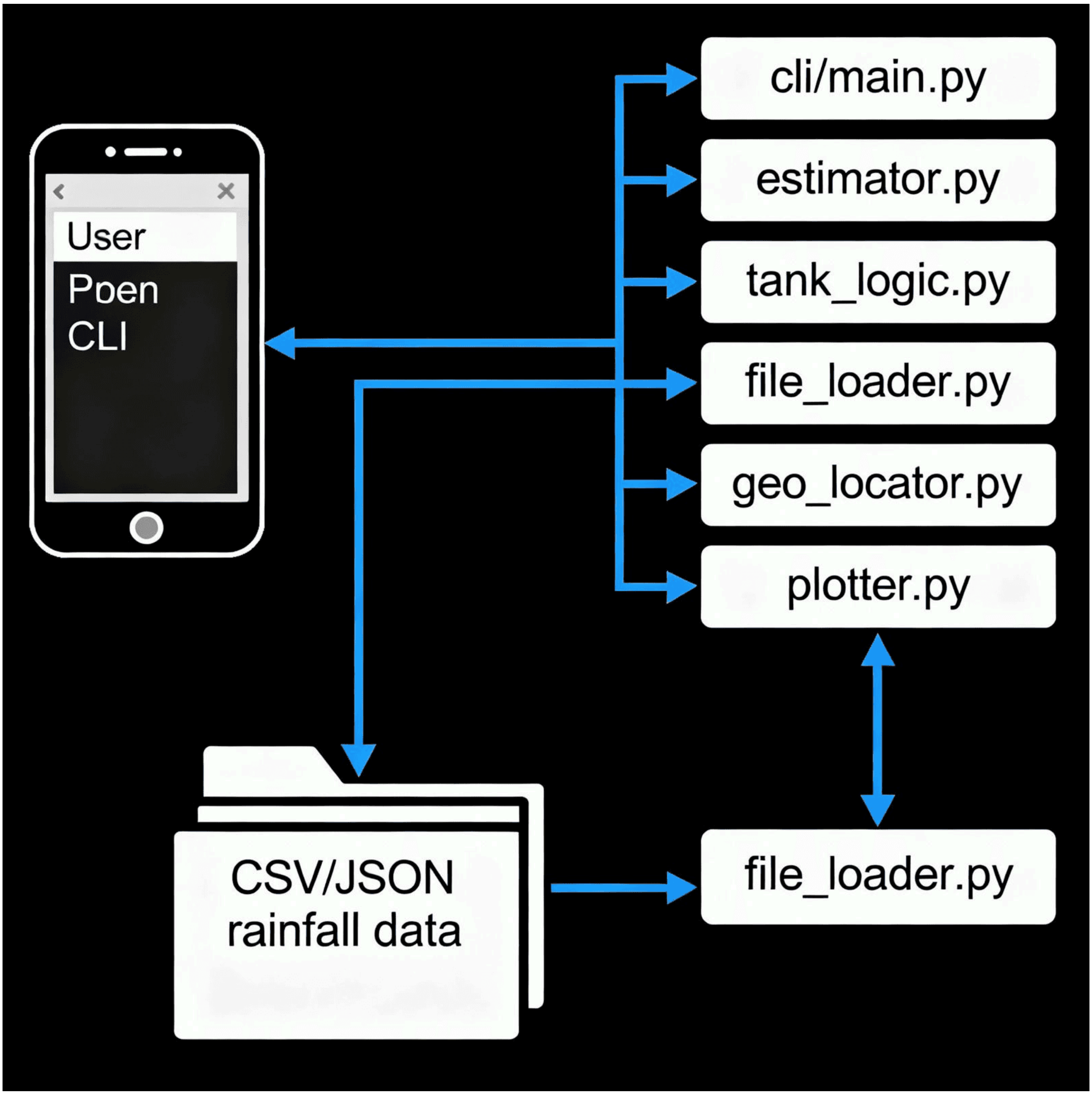
DEPLOYMENT DIAGRAM

The system consists of three primary parts:

- **User Interface (CLI):** The user interacts with the system through a Command-Line Interface. The `cli/main.py` script serves as the main entry point, orchestrating the application's workflow.
- **Core Application Modules:** The application logic is modularized into several Python scripts: `estimator.py`, `tank_logic.py`, `geo_locator.py`, `file_loader.py`, and `plotter.py`. These modules handle specific tasks like calculation, data loading, and visualization.

- **Data Storage:** Historical rainfall data is stored externally in `CSV` or `JSON` file formats. This data is accessed exclusively by the `file_loader.py` module.

The workflow begins with the user running the CLI. The `main.py` script then calls the necessary modules to load data, perform calculations, and plot results, which are finally presented back to the user through the command line.



CHAPTER 4

SYSTEM ARCHITECTURE

4.1 ARCHITECTURE OVERVIEW

The RainSense system is designed using a three-layer architecture to ensure a clear separation of concerns, modularity, and maintainability. This architectural pattern divides the application into three logical layers: the User Layer, the Processing Layer, and the Data Layer. Each layer has a specific responsibility, which simplifies development and allows for independent modification and scaling of components.

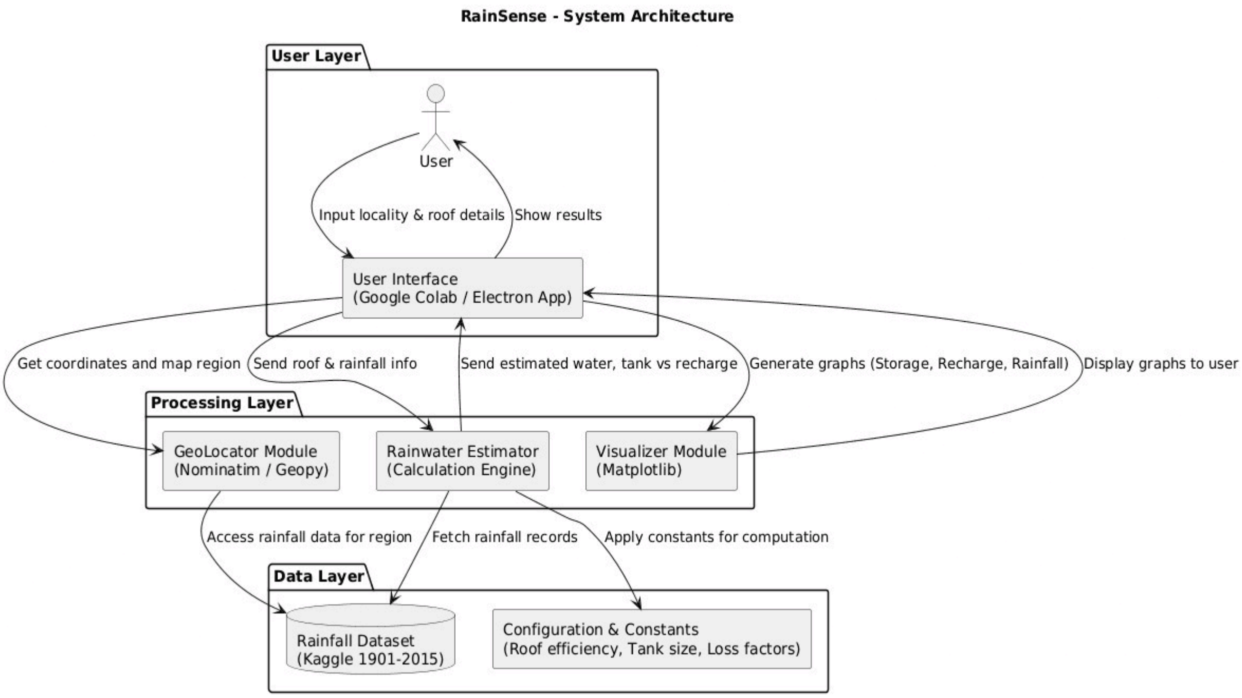


Fig: 4.1.1. System Architecture for RainSense

User Layer :

This layer is the primary entry point for all user interactions. It is responsible for gathering input from the user and presenting the final computed results in a human-readable format.

- **User:** An external actor who initiates the process by providing their locality and roof details.
- **User Interface (UI):** The front-end of the application, developed as a Google Colab notebook or a standalone Electron App. Its main functions are to:
  - Collect input parameters (locality, roof size, material, etc.).
  - Send this information to the Processing Layer for computation.
  - Receive the processed results and visualizations.
  - Display the final estimations and graphs to the user.

Processing Layer:

This is the core of the RainSense system, acting as the central engine for all logic and calculations. It processes the data received from the User Layer by interacting with the Data Layer.

- **GeoLocator Module:** This module uses services like **Nominatim** and the **Geopy** library to convert a user-provided locality name (e.g., "Chennai, Tamil Nadu") into precise geographic coordinates (latitude and longitude). These coordinates are essential for fetching the correct regional rainfall data.

- **Rainwater Estimator (Calculation Engine):** This is the central processing unit of the application. It receives the user's roof details from the UI and the geographical region from the GeoLocator. Its responsibilities include:
  - Fetching historical rainfall records for the specific region from the database.
  - Applying computational constants (e.g., roof efficiency, loss factors) to the data.
  - Calculating the estimated water collection, tank storage levels, and groundwater recharge potential over time.
- **Visualizer Module:** This module, built using the **Matplotlib** library, is responsible for creating graphical representations of the results. It receives the calculated data from the Rainwater Estimator and generates graphs illustrating trends in rainfall, water storage, and recharge, making the data easier to interpret.

Data Layer:

This layer is responsible for the storage, retrieval, and management of all data required by the system. It abstracts the data sources from the Processing Layer.

- **Rainfall Dataset:** This component houses the historical meteorological data. The primary dataset used is from **Kaggle**, containing rainfall records from 1901 to 2015. The Processing Layer queries this dataset to obtain rainfall patterns for a specific geographical region.
- **Configuration & Constants:** This repository stores static parameters and configuration values required for calculations. This includes

physical constants like **roof runoff coefficients (efficiency)**, **first-flush water loss factors**, and user-configurable parameters like **tank sizes**. Storing these separately allows for easy updates without modifying the core application logic.

4.2 System Workflow and Data Workflow

The operational flow of the RainSense system follows a logical sequence of steps, as depicted by the interactions in the architecture diagram:

1. **Input:** The User enters their locality and roof details into the User Interface.
2. **Geocoding:** The UI sends the locality information to the GeoLocator Module, which returns the corresponding geographic coordinates and map region.
3. **Data Dispatch:** The UI forwards the roof details and the map region to the Rainwater Estimator.
4. **Data Retrieval:** The Rainwater Estimator queries the Data Layer. It fetches relevant historical rainfall records from the Rainfall Dataset and pulls necessary parameters (like roof efficiency) from the Configuration & Constants store.
5. **Computation:** The Estimator applies the constants to the rainfall data and user inputs to calculate the potential volume of harvested water, tank storage dynamics, and recharge amounts.
6. **Visualization:** The calculated results are passed to the Visualizer Module, which generates a set of graphs (e.g., monthly storage vs. rainfall).
7. **Output:** The generated graphs are sent back to the User Interface, which then displays the comprehensive results and visualizations to the User, completing the request-response cycle.

CHAPTER 5

SYSTEM IMPLEMENTATION

5.1 BACKEND CODING

Configuration. py

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import kagglehub

ROOF_MATERIAL_EFFICIENCY = {'concrete': 0.85, 'metal': 0.95,
'tile': 0.80}

PIPE_LOSS = 0.95
ABSORPTION_LOSS = 0.90

STANDARD_TANK_SIZE = 1000
STANDARD_ROOF_AREA = 100

path = kagglehub.dataset_download("rajanand/rainfall-in-india")
print("Dataset downloaded at:", path)
```

geoencoding.py

```
from geopy.geocoders import Nominatim

geolocator = Nominatim(user_agent="rainwater_project")

def get_district_state(location_name):
    try:
        location = geolocator.geocode(location_name,
addressdetails=True, language="en")
        if not location or "address" not in location.raw:
            return None, None

        address = location.raw["address"]
```

```
        # Try extracting district-level fields in priority order
        district = (address.get("county") or
                    address.get("state_district") or
                    address.get("city") or
                    address.get("region"))

        state = address.get("state")

        # Fallback correction: map sub-district/locality → known
district
        corrections = {
            "Alandur": "Chennai",
            "Tambaram": "Chennai",
            "Poonamallee": "Tiruvallur",
            "Thane": "Mumbai Suburban",   # Example correction
            # Add more mappings as you encounter mismatches
        }

        if district in corrections:
            district = corrections[district]

        return district, state

    except Exception as e:
        print("Error during geocoding:", e)
        return None, None
```

rainwater_storage_visualization.py

```
def plot_rainwater_results(harvestable, annual_rainfall_mm,
roof_area, tank_size=STANDARD_TANK_SIZE):
    """
    Plot harvested water distribution (Tank vs Recharge) along
with rainfall info.

    Args:
        harvestable (float): Total harvestable rainwater in
liters.
```

```
        annual_rainfall_mm (float): Annual rainfall (mm).
        roof_area (float): Roof area (m²).
        tank_size (float): Tank capacity (liters).
    """
    # Tank vs recharge calculation
    tank_fill = min(harvestable, tank_size)
    recharge = max(0, harvestable - tank_size)

    categories = ['Tank Storage', 'Groundwater Recharge']
    values = [tank_fill, recharge]

    plt.figure(figsize=(7,5))
    bars = plt.bar(categories, values, color=['steelblue',
'seagreen'], alpha=0.8)

    # Add labels above bars
    for bar in bars:
        height = bar.get_height()
        plt.text(bar.get_x() + bar.get_width()/2, height + 100,
f"{height:.0f} L",
                 ha='center', va='bottom', fontsize=10,
fontweight='bold')

    plt.title(f"Rainwater Harvesting Potential\nRainfall:
{annual_rainfall_mm:.1f} mm | Roof Area: {roof_area} m²",
              fontsize=12, fontweight='bold')
    plt.ylabel("Water (Liters)")
    plt.grid(axis='y', linestyle='--', alpha=0.7)

    plt.show()
```

monthly_rainfall_plot.py

```
def plot_monthly_rainfall(state, district):
    record = df[(df["STATE_UT_NAME"].str.lower() ==
state.lower()) &
                (df["DISTRICT"].str.lower() == district.lower())]

    if record.empty:
```

```
        return None

    months = ["JAN","FEB","MAR","APR","MAY","JUN",
              "JUL","AUG","SEP","OCT","NOV","DEC"]
    values = [float(record[m].values[0]) for m in months]

    plt.figure(figsize=(10,6))
    plt.bar(months, values, color="skyblue")
    plt.title(f"Monthly Average Rainfall in {district}, {state}")
    plt.ylabel("Rainfall (mm)")
    plt.show()
```

rainwater_estimation.py

```
def estimate_rainwater(state, district, roof_area, material,
tank_size=STANDARD_TANK_SIZE)
    # Filter dataset
    record = df[(df["STATE_UT_NAME"].str.lower() ==
state.lower()) &
                (df["DISTRICT"].str.lower() == district.lower())]

    if record.empty:
        print(f"No rainfall data found for {district}, {state}.")
        return None

    # Get annual average rainfall (in mm)
    annual_rainfall_mm = float(record["ANNUAL"].values[0])

    # Volume of rainwater (liters) = Rainfall(mm) × Area(m²)
    volume_liters = annual_rainfall_mm * roof_area

    # Apply efficiency losses
    efficiency = (ROOF_MATERIAL_EFFICIENCY[material] * PIPE_LOSS *
ABSORPTION_LOSS)
    harvestable = volume_liters * efficiency

    # Tank vs recharge
    tank_fill = min(harvestable, tank_size)
    recharge = max(0, harvestable - tank_size)
```

```
    return harvestable, annual_rainfall_mm, tank_fill, recharge
```

main.py

```
locality = input("Enter your locality (e.g., Navi Mumbai,
Whitefield, Adyar): ")
district, state = get_district_state(locality)

if district and state:
    print(f"Resolved locality → District: {district}, State:
{state}")

    material = input(f"Enter roofing material
{list(ROOF_MATERIAL_EFFICIENCY.keys())}: ")
    area = float(input(f"Enter roof area in m² (default
{STANDARD_ROOF_AREA}): ") or STANDARD_ROOF_AREA)

    # Run estimation
    result = estimate_rainwater(state, district, area, material)

    if result:
        harvestable, annual_rainfall_mm, tank_fill, recharge =
result

        # Show text results
        print(f"\n Location: {district}, {state}")
        print(f"Annual Avg Rainfall: {annual_rainfall_mm:.2f}
mm")
        print(f"Roof Area: {area} m²")
        print(f"Estimated Harvestable Rainwater:
{harvestable/1000:.2f} KL")
        print(f"Tank Storage: {tank_fill/1000:.2f} KL")
        print(f"Groundwater Recharge: {recharge/1000:.2f} KL")

        # Show plots
        plot_monthly_rainfall(state, district)
```

```
        plot_rainwater_results(harvestable, annual_rainfall_mm,
area)

else:
    print(" Could not resolve your locality. Try again with a
nearby city/district.")
```

CHAPTER 6

PERFORMANCE EVALUATION

Performance analysis demonstrates the effectiveness, efficiency, and accuracy of the RainSense system. It includes metrics, results, and discussion to show how the system performs in estimating rooftop rainwater harvesting potential and visualizing rainfall data.

6.1. PERFORMANCE PARAMETERS

The following metrics were used to evaluate RainSense:

1. **Accuracy of Rainwater Estimation**

Verified against historical rainfall data and theoretical rooftop water calculations.Compares expected water collection (based on rainfall × roof area × efficiency) with the system's output.

2. **Response Time**

Time taken from user input to display of results.Includes geolocation mapping, data retrieval, computation, and visualization.

3. **Visualization Clarity**

Evaluates how clearly the system presents storage vs recharge and rainfall trends. Ensures graphs are easy to interpret by users.

4. **Robustness**

System’s ability to handle: Incorrect or misspelled localities, Missing rainfall data for a sub-division and Different roof material and area inputs

5. **Scalability**

Ability to handle multiple user inputs or larger datasets without significant performance degradation.

6.2. RESULTS AND DISCUSSION

Testing RainSense across different localities in India revealed that the system provides accurate estimates of harvestable rainwater and recharge potential. Calculations matched closely with theoretical values derived from rainfall, roof area, and material efficiency, demonstrating the reliability of the system’s algorithms. The visualizations were effective, with bar charts clearly distinguishing between water stored in tanks and water recharged to the ground. Monthly and annual rainfall graphs provided intuitive insights into seasonal trends, helping users understand when water collection would be highest.

The system proved to be user-friendly and robust, successfully handling incorrect locality names and missing data by issuing appropriate warnings or using default values. Integration with Nominatim ensured that most localities were mapped accurately, supporting precise rainfall data retrieval. Efficiency testing showed that the average response time for a single query was under 2–3 seconds on standard hardware, and performance remained consistent even when larger roof areas or multiple user inputs were processed simultaneously.

However, some limitations were observed. The system's accuracy depends on the completeness of the historical rainfall dataset, and geo-mapping may occasionally fail for very small or newly formed localities. Additionally, RainSense currently does not incorporate real-time rainfall data or IoT-based monitoring, which could enhance precision in future versions.

In conclusion, the performance analysis demonstrates that RainSense is a reliable and practical tool for estimating rooftop rainwater harvesting potential. Its combination of accurate calculations, clear visualizations, and robust error handling makes it suitable for both academic demonstration and practical guidance for implementing RRWH systems.

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1. CONCLUSION

The RainSense project demonstrates the practical potential of **rooftop rainwater harvesting (RRWH)** using a data-driven, user-friendly system. By integrating historical rainfall data, geolocation services, and roof material efficiencies, the system accurately estimates the amount of water that can be stored in rooftop tanks and recharged to the ground. Visualizations, including bar charts and rainfall trend graphs, provide intuitive insights into seasonal and annual rainfall patterns, making it easier for users to understand the benefits of implementing RRWH systems.

The system proved to be robust and efficient, handling various user inputs, including different localities, roof areas, and roof materials. It successfully processes large datasets while maintaining quick response times and clear graphical outputs. RainSense not only serves as a practical tool for individual households but also demonstrates the importance of scientifically planned rainwater harvesting for **sustainable water management**.

7.2. FUTURE ENHANCEMENT

While RainSense performs effectively in its current form, there are several opportunities for future improvements. The system could be enhanced by incorporating **real-time rainfall data** using IoT-based sensors, which would allow for more accurate predictions and dynamic water management. Integration with **smart home systems** could automate the monitoring and storage of harvested water, optimizing usage and reducing waste.

Another key enhancement is the **collaboration with NGOs and government bodies** to promote wider adoption of rooftop rainwater harvesting. By sharing data and insights, RainSense could help municipal authorities and environmental organizations identify high-potential areas for water harvesting, design community-level programs, and ensure compliance with regional water sustainability policies. Such partnerships could expand the system's impact from individual households to entire communities, driving large-scale water conservation initiatives.

Additional improvements could include expanding the geolocation module to cover smaller or newly developed localities, integrating regional climate projections for long-term planning, and enabling multi-user scenarios for community-level rainwater management. y implementing these enhancements, RainSense could evolve into a comprehensive, smart RRWH system that promotes sustainable water practices at individual, community, and governmental levels, contributing significantly to water conservation and urban sustainability.

CHAPTER 8

APPENDICES

A1. SDG GOALS

The RainSense project contributes to the following **Sustainable Development Goals (SDGs):**

1. **SDG 6 – Clean Water and Sanitation:** RainSense contributes to this goal by promoting rooftop rainwater harvesting, which increases the availability of freshwater for domestic and community use. By capturing and storing rainwater, the system reduces dependence on conventional water sources such as groundwater and municipal supply. This approach helps address water scarcity, ensures sustainable access to clean water, and encourages responsible water consumption at both household and community levels.
2. **SDG 12 – Responsible Consumption and Production:** The project aligns with this goal by facilitating efficient and sustainable use of water resources. RainSense enables users to manage rainwater effectively, minimizing wastage and promoting recycling through groundwater recharge. By optimizing water collection and utilization, the system supports environmentally responsible practices and encourages users to adopt sustainable resource management in daily life.

These goals emphasize the environmental and societal impact of the project, demonstrating its relevance to sustainable urban development.

A2. SCREENSHOTS

```
C:\Project\RainSense>python main.py
Enter your locality (e.g., Navi Mumbai, Whitefield, Adyar): Avadi
Resolved locality → District: Tiruvallur, State: Tamil Nadu
Enter roofing material ['concrete', 'metal', 'tile']: concrete
Enter roof area in m² (default 100): 120

 Location: Tiruvallur, Tamil Nadu
Annual Avg Rainfall: 1139.60 mm
Roof Area: 120.0 m²
Estimated Harvestable Rainwater: 99.38 KL
Tank Storage: 1.00 KL
Groundwater Recharge: 98.38 KL
```

Fig:A.8.1. Screenshot of CLI Based Output

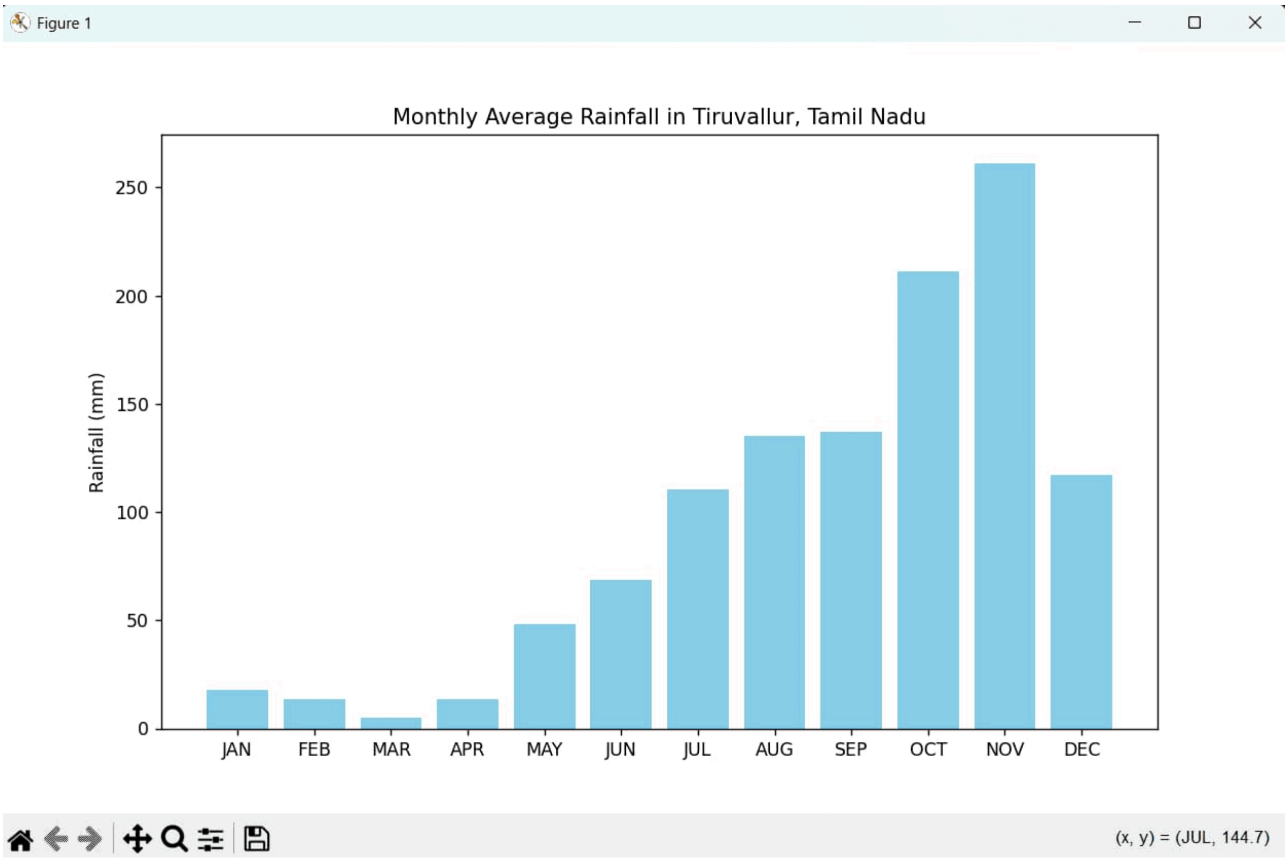


Fig A.8.2. Screenshot of Monthly Average Rainfall Graph

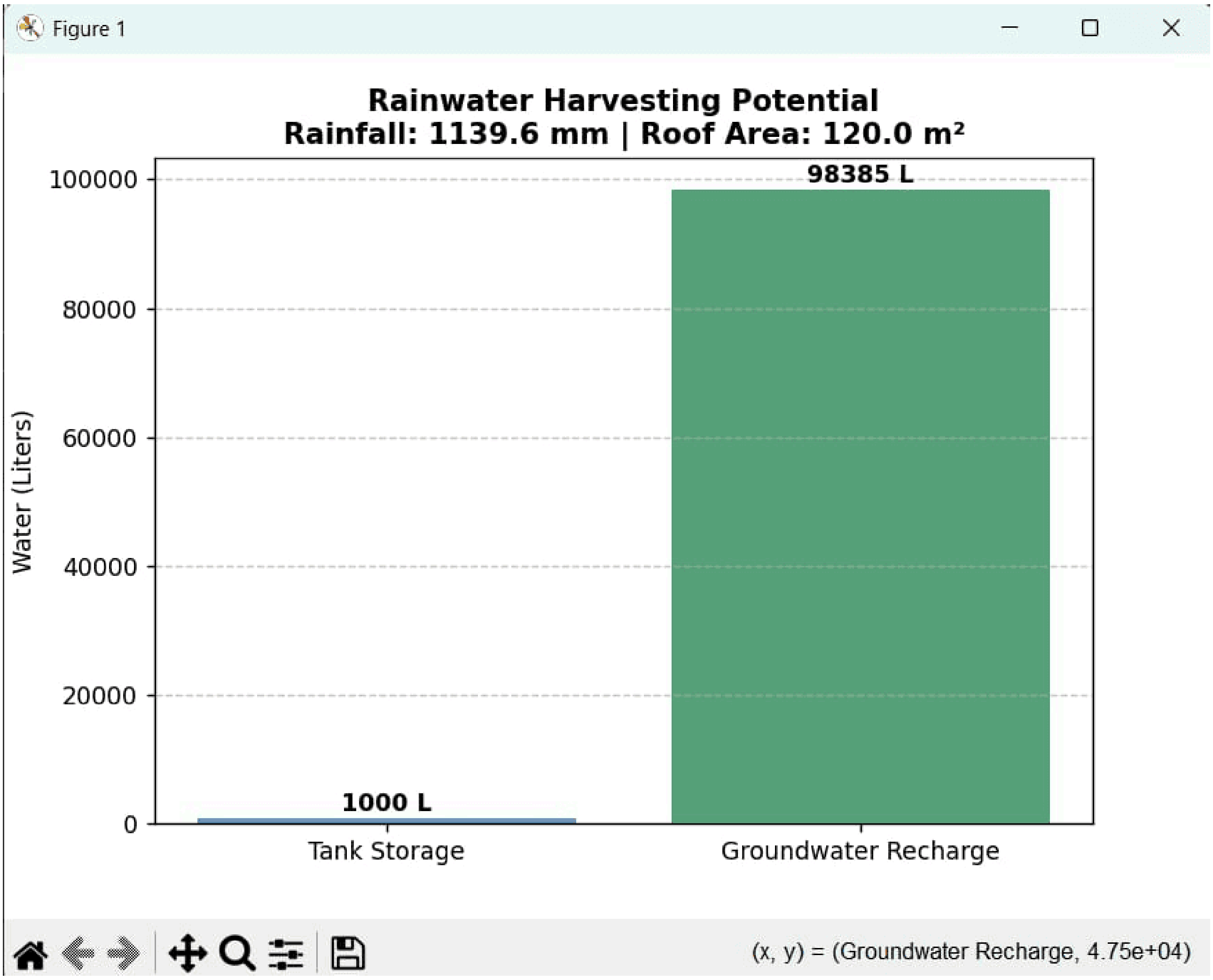


Fig:A.8.3.Screenshot of Groundwater recharge and tank water storage estimate

A3. PAPER PUBLICATION

RainSense: A Smart Estimator for Rooftop Rainwater Harvesting System

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Abstract—One of the biggest hurdles of the modern world is water shortage. Ironically enough, even regions receiving a lot of rainfall do face severe shortages because most of the water is lost to runoff. While rooftop rainwater harvesting (RRWH) is a viable means of combating this loss, its use is frequently hindered by the problem of effectively determining what can actually be harvested.We developed RainSense, a Python tool to estimate the amount of rainwater rooftops can collect. It takes into account roof area, type of material, and water loss in collection due to the roofing material. It operates on large datasets, associate results with a particular location, and generate simple plots. These aspects make it useful to household owners who need to conserve water as well as the government and planners who are planning city-level systems. In place of general assumptions, RainSense provides realistic estimations that render water management decisions more dependable and user-friendly

Index Terms—Python CLI, sustainable water management, estimation model, rainwater harvesting, water conservation

1. Introduction

Most parts of the world face declining water supplies, even as rainfall is still copious in certain regions, particularly in nations such as India. The issue is that most of this water flows over surfaces and goes to waste since there is no method of holding such additional rainwater. Collecting rainwater in lakes and tanks has a maximum limit, and if they are saturated, then the surplus rainwater cannot be held, resulting in water wastage. Harvesting rainfall from rooftops is an easy means of harvesting some of that loss and minimizing stress on municipal systems.

To put this into action, however, an estimation of how much water a rooftop can actually hold needs to be determined, which is a bit challenging. That can be based on aspects such as roof size, material used, and rainfall intensity. To ensure this was easy to use, we developed RainSense, a light command-line application which performs the calculation for you. It estimates rooftop harvesting potential, can process large datasets, and reports in easy-to-read format. With this, both residents and city planners can make more practical water use decisions.

2. Problem Statement

Water shortages occur in most regions even when rainfall is adequate because of poor management. Existing rooftop rainwater harvesting programs may not succeed due to users not having easy and reliable ways to determine their potential. The existing methods are time-consuming with calculations, estimations of roof sizes, and studies of precipitation patterns. There is an obvious need for an accurate, accessible tool that can provide useful results with limited user input.

RainSense fills the void by automating the estimation process and providing results in a user-friendly format.

3. Literature Review

In the last few years, extensive research on rooftop rainwater harvesting was carried out. The feasibility of utilizing RRWH to decrease urban dependence on conventional water sources was investigated by Reddy and Kumar [1]. Sharma et al. [2] assessed rainwater harvesting systems in semi-arid regions where the scarcity of water is severe. Thomas and Andrews [3], while Meena and Jain [4] brought into focus its importance for water sustainability in Indian cities for sustainable urban development. Patel and Sinha [6] assessed the viability of RRWH in residential buildings, while Chatterjee et al. [5] tested the efficiency of RRWH systems in Eastern India. Cost benefit analyses conducted by Bhatia and Kumar [7] proved the economic feasibility of such systems. Singh [8] gave a detailed account of water conservation using RRWH, and Sharma and Verma [9] analyzed its application in urban water management practices. Current studies have utilized advanced methods and techniques. Gupta and Prasad [11] dealt with climate urban planning, while Desai et al. [10] enhanced RRWHdesigns for the coast. Yadav et al. [12] analyzed the use of harvested rainwater for drinking.

A4. PLAGIARISM REPORT

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CHAPTER 9

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