CREATING BASIC MAPS TO DISPLAY POPULATION DENSITY OF INDIAN STATES

A PROJECT REPORT

Submitted by

MOHAMED FIRDOUS S (2303811724321067)

in partial fulfillment of requirements for the award of the course

AGI1252 - FUNDAMENTALS OF DATA SCIENCE USING R

in

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY

(An Autonomous Institution, affiliated to Anna University Chennai and Approved by AICTE, New Delhi)

SAMAYAPURAM – 621 112

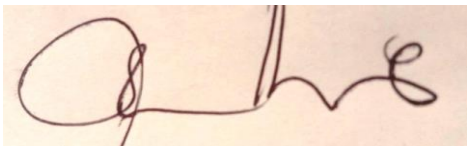
JUNE- 2025

K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY (AUTONOMOUS)

SAMAYAPURAM – 621 112

BONAFIDE CERTIFICATE

Certified that this project report on **"CREATING BASIC MAPS TO DISPLAY POPULATION DENSITY OF INDIAN STATES"** is the bonafide work of **MOHAMED FIRDOUS S (2303811724321067)** who carried out the project work during the academic year 2024 - 2025 under my supervision.



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Submitted for the viva-voce examination held on ……**02.06.2025**.

INTERNAL EXAMINER

EXTERNAL EXAMINER

DECLARATION

I declare that the project report on **"CREATING BASIC MAPS TO DISPLAY POPULATION DENSITY OF INDIAN STATES"** is the result of original work done by me and best of my knowledge, similar work has not been submitted to **"ANNA UNIVERSITY CHENNAI"** for the requirement of Degree of **BACHELOR OF TECHNOLOGY**. This project report is submitted on the partial fulfilment of the requirement of the completion of the course **AGI1252 - FUNDAMENTALS OF DATA SCIENCE USING R**

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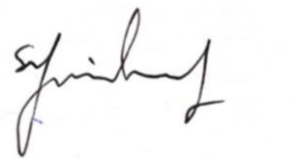

Signature

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MOHAMED FIRDOUS S

Place: Samayapuram

Date:30.05.2025

ACKNOWLEDGEMENT

It is with great pride that I express our gratitude and in-debt to our institution "**K.Ramakrishnan College of Technology (Autonomous)**", for providing us with the opportunity to do this project.

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I wish to express our special thanks to the officials and Lab Technicians of our departments who rendered their help during the period of the work progress.

INSTITUTE

Vision:

- To serve the society by offering top-notch technical education on par with global standards.

Mission:

- Be a center of excellence for technical education in emerging technologies by exceeding the needs of industry and society.
- Be an institute with world class research facilities.
- Be an institute nurturing talent and enhancing competency of students to transform them as all – round personalities respecting moral and ethical values.

DEPARTMENT

Vision:

- To excel in education, innovation, and research in Artificial Intelligence and Data Science to fulfil industrial demands and societal expectations.

Mission

- To educate future engineers with solid fundamentals, continually improving teaching methods using modern tools.
- To collaborate with industry and offer top-notch facilities in a conducive learning environment.
- To foster skilled engineers and ethical innovation in AI and Data Science for global recognition and impactful research.
- To tackle the societal challenge of producing capable professionals by instilling employability skills and human values.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

- **PEO1:** Compete on a global scale for a professional career in Artificial Intelligence and Data Science.
- **PEO2:** Provide industry-specific solutions for the society with effective communication and ethics.
- **PEO3** Enhance their professional skills through research and lifelong learning initiatives.

PROGRAM SPECIFIC OUTCOMES (PSOs)

- **PSO1:** Capable of finding the important factors in large datasets, simplify the data, and improve predictive model accuracy.
- **PSO2:** Capable of analyzing and providing a solution to a given real-world problem by designing an effective program.

PROGRAM OUTCOMES (POs)

Engineering students will be able to:

1. **Engineering knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals, and an engineering specialization to develop solutions to complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.

3. **Design/development of solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.

4. **Conduct investigations of complex problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.

5. **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.

6. **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.

7. **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.

8. **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

9. **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

10. **Project management and finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

11. **Life-long learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

ABSTRACT

This project presents **"Density Viewer"**, an interactive web-based dashboard developed using **R Shiny**. The system allows users to upload custom datasets and explore **state-wise population density** data across India. The dashboard features dynamic **table views** with filtering options to highlight states with the highest or lowest densities, and an **interactive map** generated using the leaflet package to visualize the data geographically. Color gradients help users interpret density levels at a glance.The application emphasizes real-time responsiveness through **reactive programming**, ensuring that any data updates or filter changes reflect instantly. The dashboard is user-friendly, scalable, and supports informed decision-making in fields like **urban planning, public health**, and **resource allocation**. By integrating **modern data science tools** and intuitive visualization, the project demonstrates how **R programming** can effectively bridge complex data with accessible insights, aligning with program-specific outcomes of data analysis and real-world problem-solving through software solutions.

ABSTRACT WITH POs AND PSOs MAPPING

CO 5 : BUILD DATA SCIENCE USING R PROGRAMMING FOR SOLVING REAL-TIME PROBLEMS.

ABSTRACT	POs MAPPED	PSOs MAPPED
This project introduces a web-based interactive dashboard named "Density Viewer" using R and Shiny. It allows users to upload datasets, view state-wise population densities, and visualize the data interactively on a map.	**PO1 -3** **PO2 -3** **PO3 -3** **PO4 -3** **PO5 -3** **PO6 -2** **PO7 -2** **PO8 -2** **PO9 -3** **PO10 -2** **PO11-3**	**PSO1 -3** **PSO2 -3**

Note: 1- Low, 2-Medium, 3- High

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1. INTRODUCTION

1.1 Objective :

The main objective of this project is to design and implement an interactive dashboard named **"Density Viewer"** that enables users to visualize and analyze the population density of Indian states. The dashboard is developed using **R and Shiny** to provide a clean, user-friendly interface. Users can upload their CSV files containing state-wise population density data and explore the distribution through an interactive **map and data table**. The tool allows filtering options to highlight states with **highest** or **lowest** population densities. This promotes insightful interpretation of data, enabling government bodies, researchers, and policy planners to make informed decisions for **urban planning**, **infrastructure development**, and **resource allocation** based on the demographic distribution across Indian states.

1.2 Overview

This project introduces a real-time **interactive web dashboard** that aids in understanding the population density distribution across India. By using visualization tools, it allows users to upload data, apply filters, and view density levels on a **color-coded map**. The application improves data accessibility and facilitates easier interpretation for non-technical stakeholders. Through a combination of **tabular data representation** and **geographical mapping**, users can examine density hotspots or sparsely populated areas. The integration of these tools helps in demographic studies, smart city planning, emergency resource deployment, and policy making. The system is designed to be flexible, scalable, and interactive, ensuring a better user experience and deeper insight into **state-level demographic information** across the country.

1.3 Data Science related concepts

The project utilizes several powerful R packages to build a fully functional dashboard.

- The **shiny** package is used to create the interactive web-based user interface and reactive server logic.
- The **leaflet** package enables rendering of maps to visually represent the population density data, using **color gradients** to distinguish between high and low values.
- The **dplyr** package is employed for data manipulation, filtering, and joining datasets like user-uploaded CSVs with state coordinates.
- Finally, **DT** is used to render dynamic, interactive tables that support real-time filtering and searching.

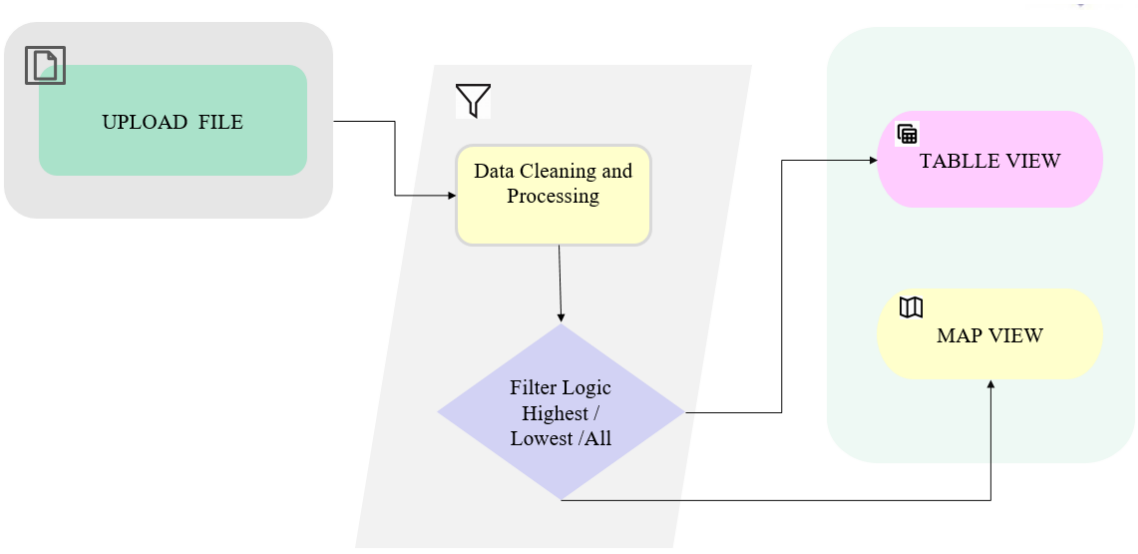
These R tools together enable the creation of a highly interactive and visually informative dashboard that allows users to explore, analyze, and understand population density effectively in an engaging format.

2. PROJECT METHODOLOGY

2.1 Proposed Work

The proposed work aims to develop an interactive R Shiny dashboard that enables users to upload CSV files containing state-wise population density data. The system merges this data with predefined geographic coordinates and provides filter options to display the states with the highest or lowest population densities. The processed data is visualized using an interactive Leaflet map with color gradients and an accompanying data table, offering a comprehensive view of demographic distribution across Indian states.

2.2 Block Diagram User Interaction Flow:



3. MODULE DESCRIPTION

3.1 DATA UPLOAD & CLEANING MODULE

Purpose:

The Data Upload & Cleaning Module is responsible for handling input files and preparing raw population density data for analysis. It ensures the data is clean, formatted correctly, and ready for downstream processing.

Description:

This module allows users to upload a CSV file containing state-wise population density data. Once uploaded, the system reads the data using read.csv() and cleans it by removing unnecessary characters (e.g., commas) and ensuring appropriate data types. It then merges this data with geolocation coordinates for each state. The cleaned dataset is then made available to all other modules. This preprocessing ensures accuracy and consistency in visualizations and tabular representations.

Key Functions:

1. **Upload Data File:** Accepts CSV files and reads data into R.
2. **Clean Data Fields:** Formats numeric fields and ensures type correctness.
3. **Merge with Coordinates:** Joins dataset with latitude and longitude for each state.
4. **Validation:** Ensures uploaded file has all required columns like "State" and "Density."

3.2 TABLE VIEW MODULE

Purpose:

The Table View Module displays the processed population density data in an interactive table format that allows for searching, filtering, and sorting.

Description:

This module uses the DT package to create an interactive and user-friendly table. It displays all cleaned data and allows users to apply filters to view states with the highest or lowest densities or the full dataset. The table auto-updates when new data is uploaded or filters are changed. It helps users who prefer textual or tabular insight into population distribution.

Key Functions:

1. **Interactive Table Display:** Shows cleaned data in a searchable, paginated format.
2. **Filtering Options:** Lets users filter for highest, lowest, or all densities.
3. **Responsive Updates:** Automatically updates when inputs or data change.
4. **Sorting:** Allows sorting by state or density.

3.3 MAP VISUALIZATION MODULE

Purpose:

The Map Visualization Module provides a visual representation of population density across different states of India using color-coded markers on a map.

Description:

Built with the leaflet package, this module creates a dynamic map where each state is marked with a colored circle. The color represents the population density level—low (green), medium (yellow), high (red). Hovering over each marker shows the exact state and its population density. This visualization helps users understand regional density patterns at a glance.

Key Functions:

1. **Map Generation:** Renders a leaflet map with state-level markers.
2. **Color-Coding by Density:** Uses conditional coloring to indicate density levels.
3. **Interactive Tooltips:** Displays state names and density values on hover.
4. **Legend Integration:** Includes a legend for easy interpretation of color codes.

3.4 USER INTERFACE DESIGN USING SHINY

Purpose:

This module handles the layout and interactive design of the application, ensuring user-friendly access to features like data upload, filtering, and visualization.

Description:

Using Shiny's fluidPage(), sidebarLayout(), and tabsetPanel(), this module organizes the application into a clean, intuitive interface. The sidebar contains input elements such as file upload and filter selection, while the main panel displays outputs like the table and map. It ensures a smooth user experience, even for users unfamiliar with R.

Key Functions:

1. **Tab-Based Layout:** Divides the app into "Table View" and "Map View" tabs.
2. **Sidebar Controls:** Includes file input and density filter selection.
3. **Responsive Design:** Automatically adjusts layout based on screen size.
4. **Output Display:** Dynamically renders map and table outputs in the main panel.

3.5 INTEGRATION AND TESTING MODULE

Purpose:

This module ensures seamless interaction between all components and validates that the app behaves correctly under various conditions.

Description:

This module binds all parts of the application—data upload, table view, map view, and user interface—through reactive programming. It includes validation checks, error messages for incorrect input formats, and real-time updates when inputs change. The module is tested using different datasets to confirm reliability, responsiveness, and performance.

Key Functions:

1. **Reactive Coordination:** Links input and output modules through reactive expressions.
2. **Error Handling:** Displays messages for invalid file uploads or missing data fields.
3. **Testing:** Ensures functionality with various test datasets and edge cases.
4. **Performance Monitoring:** Checks for lag and resolves performance issues.

4. CONCLUSION

The **Population Density Visualization System** developed using **R programming** and **Shiny** offers a powerful and interactive platform for analyzing and understanding population distribution across Indian states. By leveraging data visualization tools such as **Leaflet** for mapping and **DT** for interactive tables, the system transforms raw population data into meaningful insights. The **Data Upload and Cleaning module** ensures reliable input by formatting and preparing data accurately, while the **Table View and Map Visualization modules** provide clear, comparative analysis through both textual and graphical formats.

The **User Interface**, built using Shiny's dynamic components, allows users to upload, filter, and explore data intuitively, making the system accessible to both technical and non-technical users. Integration of **reactive programming** ensures real-time responsiveness, and robust error handling maintains the stability of the application. Overall, the system offers an effective, scalable, and user-friendly solution for demographic data visualization and decision support.

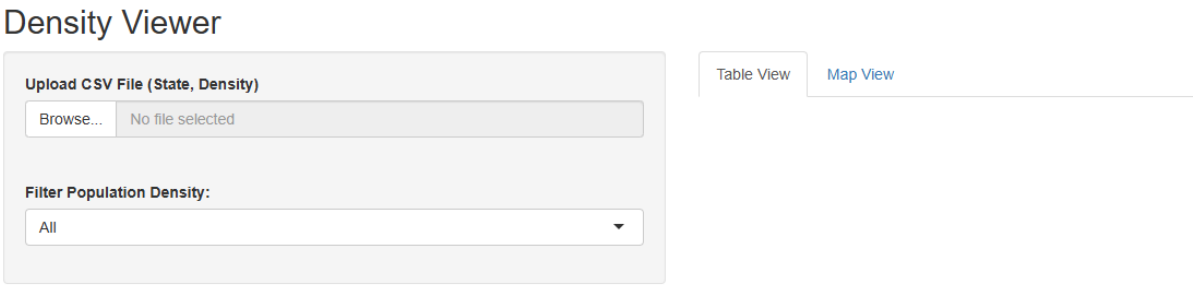
5. APPENDIX A SOURCE CODE

```
library(shiny)
library(DT)
library(leaflet)
library(dplyr)

state_coords <- data.frame(
  State = c("Uttar Pradesh", "Bihar", "Maharashtra", "West Bengal", "Tamil Nadu",
            "Rajasthan", "Karnataka", "Gujarat", "Andhra Pradesh", "Madhya Pradesh"),
  Lat = c(26.85, 25.59, 19.75, 22.57, 11.12, 27.02, 15.31, 22.26, 15.91, 23.52),
  Lon = c(80.91, 85.13, 75.71, 88.36, 78.15, 74.22, 75.71, 72.57, 79.74, 77.81)
)

ui <- fluidPage(
  titlePanel("Density Viewer"),

  sidebarLayout(
    sidebarPanel(
      fileInput("file", "Upload CSV File (State, Density)", accept = ".csv"),
      selectInput("filter_type", "Filter Population Density:",
                  choices = c("All", "Highest Density", "Lowest Density"))
    ),

    mainPanel(
      tabsetPanel(
        tabPanel("Table View", DTOutput("density_table")),
        tabPanel("Map View", leafletOutput("density_map", height = 600))
      )
    )
  )
)

server <- function(input, output) {

  user_data <- reactive({
    req(input$file)
    df <- read.csv(input$file$datapath, stringsAsFactors = FALSE)

       df$Density <- as.numeric(gsub(",", "", df$Density))

        merged <- df %>%
      inner_join(state_coords, by = "State")

    merged
  })

  filtered_data <- reactive({
    data <- user_data()
    if (input$filter_type == "Highest Density") {
```

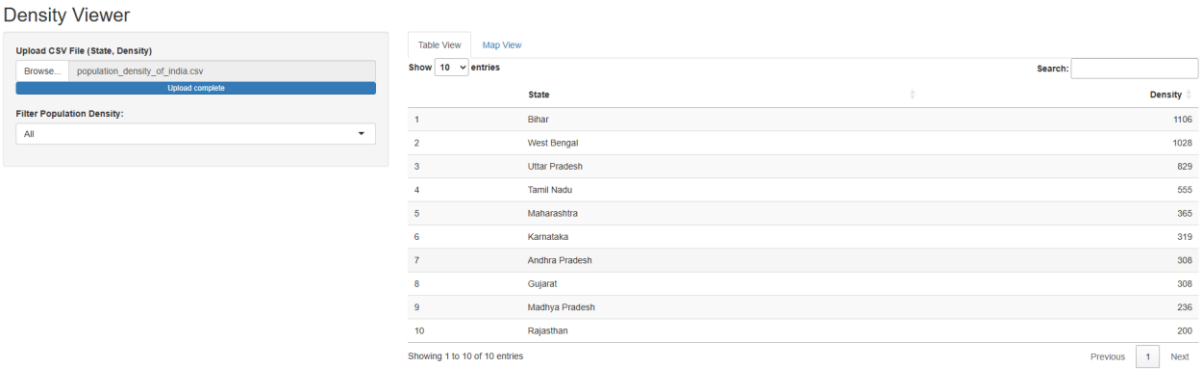
```
    data %>% filter(Density == max(Density, na.rm = TRUE))
   } else if (input$filter_type == "Lowest Density") {
    data %>% filter(Density == min(Density, na.rm = TRUE))
   } else {
    data
   }
  })

  output$density_table <- renderDT({
   datatable(filtered_data()[, c("State", "Density")], options = list(pageLength = 10))
  })

  output$density_map <- renderLeaflet({
   req(filtered_data())
   pal <- colorNumeric(palette = c("green", "yellow", "red"), domain = user_data()$Density)

   leaflet() %>%
    addTiles() %>%
    addCircleMarkers(data = filtered_data(),
                     lat = ~Lat,
                     lng = ~Lon,
                     radius = 10,
                     color = ~pal(Density),
                     stroke = TRUE,
                     fillOpacity = 0.8,
                     label = ~paste(State, ": ", Density)) %>%
    addLegend("bottomright", pal = pal, values = user_data()$Density,
              title = "Population Density")
  })
}

shinyApp(ui = ui, server = server)
```

APPENDIX B SCREENSHOTS

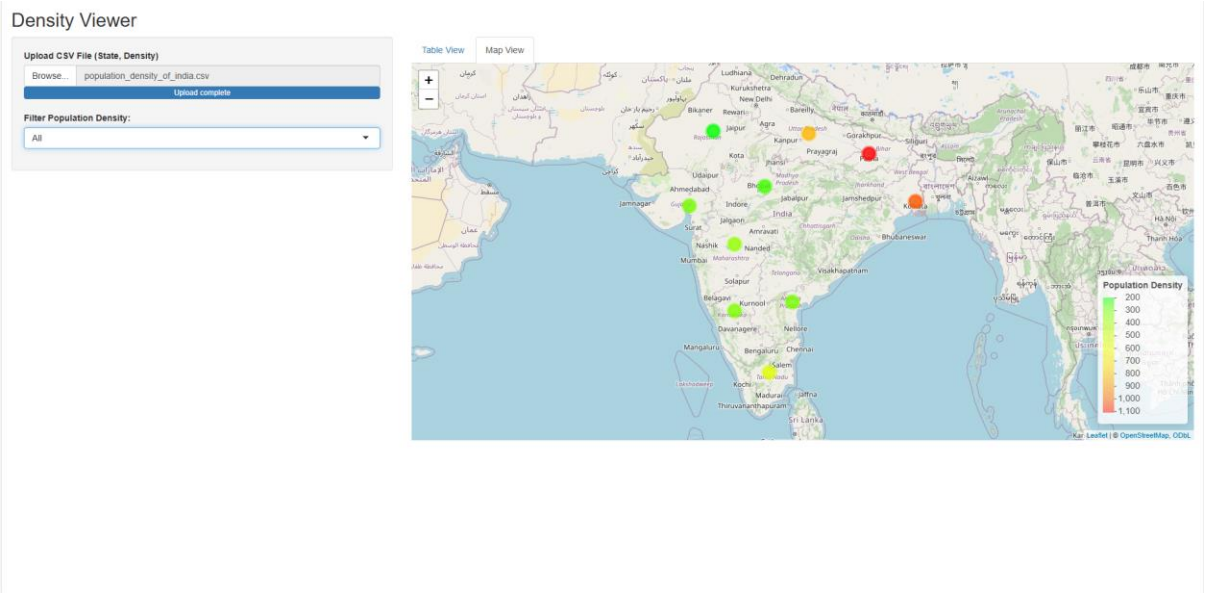
1. DASHBOARD



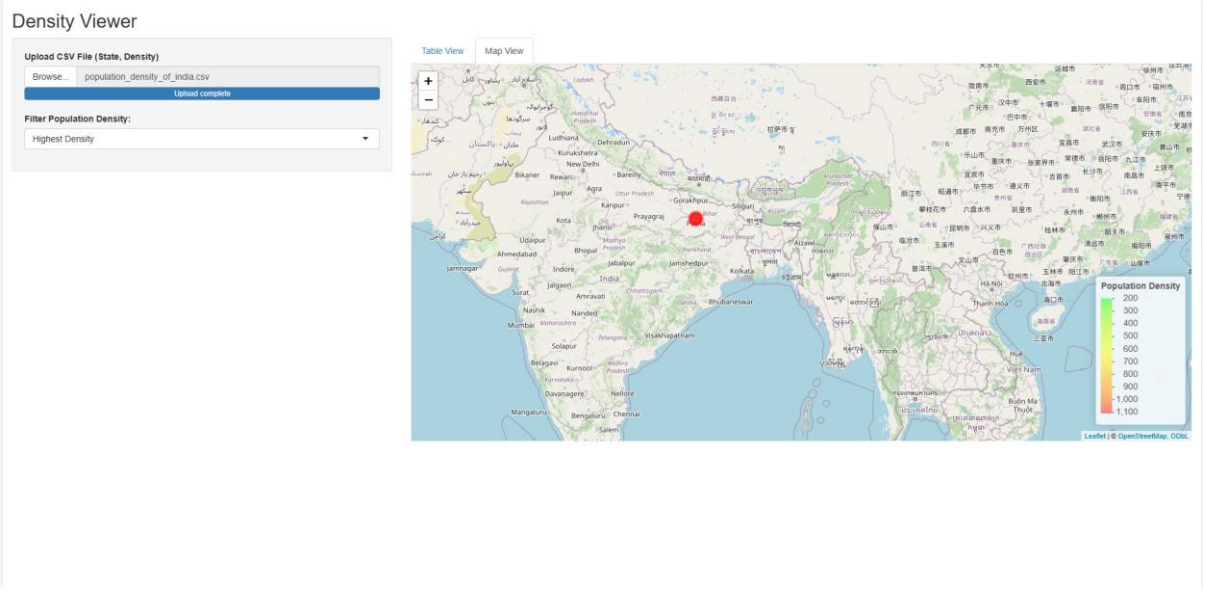
2. AFTER FILE UPLOAD



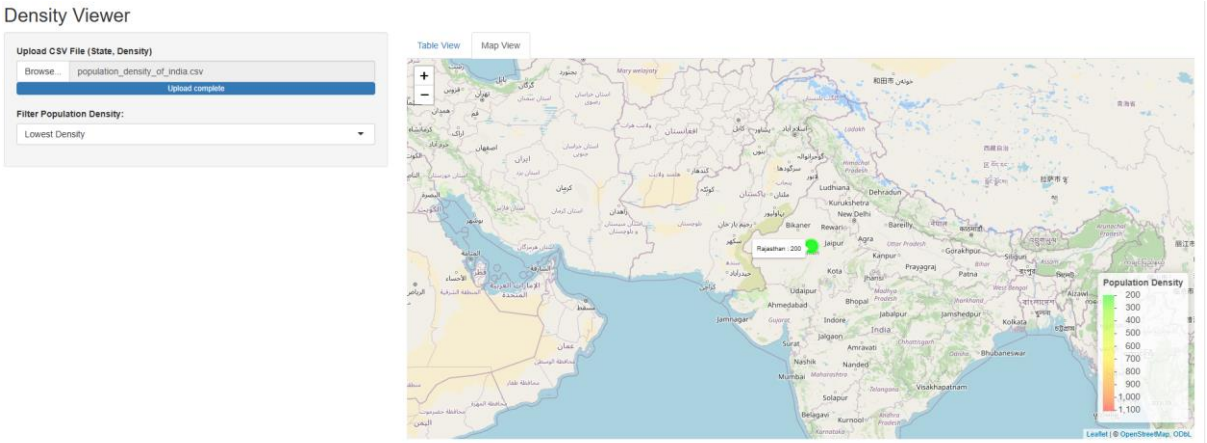
3. ALL POPULATION DENSITY



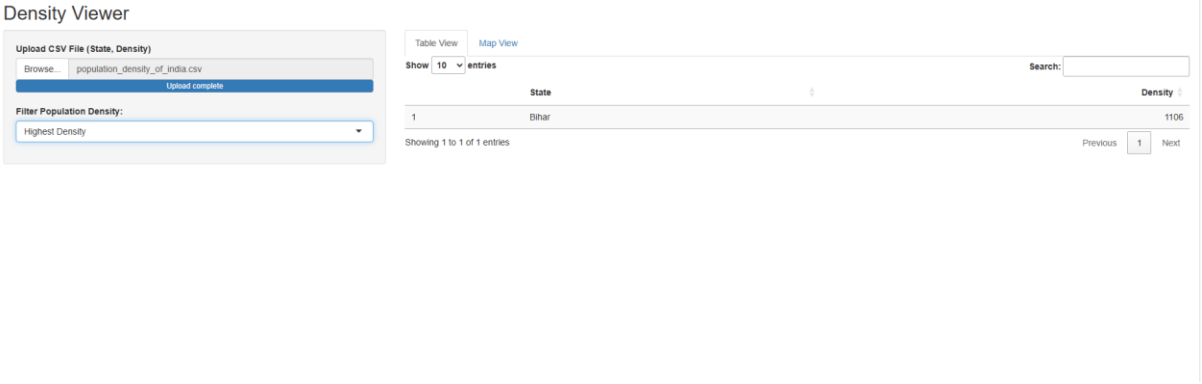
4. HIGHEST POPULATION DENSITY



5. LOWEST POPULATION DENSITY



6. TABLE VIEW



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5. Wickham, H., & Grolemund, G. (n.d.). Tidy Data. Journal of Statistical Software, 59(10), 1–23. (Optional academic source if you want a 5th reference; remove if not needed)