**R code for Map**

# Install required packages if you haven't already

install.packages("readxl")

install.packages("ggplot2")

install.packages("dplyr")

install.packages("maps")

install.packages("viridis")

install.packages("sf") # For better handling of spatial data

# Load libraries

library(readxl)

library(ggplot2)

library(dplyr)

library(maps)

library(viridis)

library(sf)

# Read the Excel file

data <- read\_excel("Cities and coordinates.xlsx")

# Check for missing values and filter them out

data <- data %>%

filter(!is.na(Latitude) & !is.na(Longitude))

# Display the first few rows of the data

head(data)

# Get Pakistan map data

pakistan\_map <- map\_data("world", region = "Pakistan")

# Create a base plot

p <- ggplot() +

geom\_polygon(data = pakistan\_map, aes(x = long, y = lat, group = group), fill = "lightgrey") +

coord\_fixed(1.3) + # Maintain aspect ratio

labs(title = "Rust Isolates Collected from Different Areas in Pakistan",

x = "Longitude",

y = "Latitude") +

theme\_minimal() +

theme(legend.position = "right")

# Add points for isolates

p <- p + geom\_point(data = data, aes(x = Longitude, y = Latitude, color = Province), size = 1, alpha = 0.7)

# Add province names as labels

province\_centers <- data %>%

group\_by(Province) %>%

summarize(Latitude = mean(Latitude), Longitude = mean(Longitude))

p <- p + geom\_text(data = province\_centers, aes(x = Longitude, y = Latitude, label = Province),

size = 2, vjust = -1, color = "black")

# Finalize the plot

p + scale\_color\_manual(values = c("Punjab" = "blue", "Sindh" = "yellow", "KPK" = "darkgreen", "Balochistan" = "red", "AJK" = "violet"))

# Use viridis color palette

ggsave("rust\_isolates\_map\_pakistan.png", width = 20, height = 6)

