CO2 Emissions, By Nation

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Information About Dataset

Per Country CO2 Emissions from fossil-fuels annually since 1751 till 2014.

Data comes from the Carbon Dioxide Information Analysis Center (CDIAC).

Information About Dataset

	Year	Country	Total	Solid Fuel	Liquid Fuel	Gas Fuel	Cement	Gas Flaring	Per Capita	Bunker Fuels
1	1949	AFGHANISTAN	4	4	0	0	0	0	0.00	0
2	1950	AFGHANISTAN	23	6	18	0	0	0	0.00	0
3	1951	AFGHANISTAN	25	7	18	0	0	0	0.00	0
•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
17230	2012	ZIMBABWE	2125	917	1006	0	201	0	0.15	9
17231	2013	ZIMBABWE	3184	1902	1119	0	162	0	0.21	9
17232	2014	ZIMBABWE	3278	2097	1005	0	177	0	0.22	9

The appearance of this table has been obtained after editing.

Preparation Steps In Brief

```
library("ggplot2")
library("cowplot")
dataset = read.csv(file = "fossil-fuel-co2-emissions-by-nation.csv",header = TRUE,
                   sep = ",")
dataset = data.frame(dataset, check.rows = TRUE)
```

```
any(dataset=="." | dataset=="_" | dataset=="-" | dataset=="!"
   |dataset== "?"| dataset== " "| dataset== "")
```

```
dataset <- dataset[order(dataset$Country,decreasing = FALSE),]
rownames(dataset) <- NULL
```

Research Questions

Are there similarities in the rate of fuel use in geographically close countries?

What are the factors that have increased the use of emissions in countries in recent years?

How did the increase in fuel use increase per capita carbon dioxide emissions?

Checking a Correlations

```
cor4plot <- round(cor(cbind(dataset[1],dataset[3:10])),2)
```

```
get_lower_tri <- function(cormat){
    cormat[upper.tri(cormat)]<- NA
    return(cormat)}

cor4plot <- get_lower_tri(cor4plot)
```

Checking a Correlations

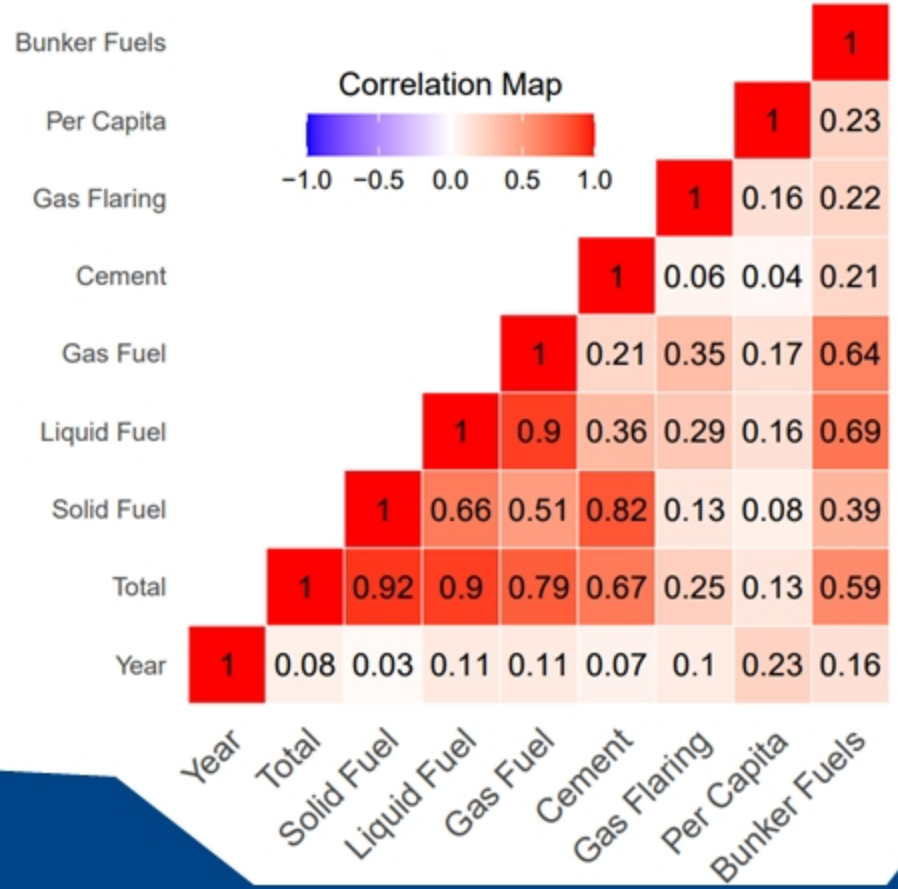
```
melted_cor <- melt(cor4plot, na.rm = TRUE)
```

```
df4cor <- data.frame(row=rownames(melted_cor)[row(melted_cor)],
                     col=colnames(melted_cor)[col(melted_cor)],
                     corr=c(melted_cor))
```

Checking a Correlations

```
ggheatmap <- ggplot(data = melted_cor, aes(x=Var1, y=Var2, fill=value)) +
      geom_tile(color = "white") +
      scale_fill_gradient2(low = "blue", high = "red", mid = "white",
      midpoint = 0, limit = c(-1,1), space = "Lab", name ="Correlation Map")+
      theme_minimal()+
      theme(axis.text.x= element_text(angle= 45, vjust= 1,size= 12,hjust= 1))+
      coord_fixed()

ggheatmap +
      geom_text(aes(Var1, Var2, label = value), color = "black", size = 4) +
      theme(axis.title.x = element_blank(), axis.title.y = element_blank(),
            panel.grid.major = element_blank(),panel.border = element_blank(),
            panel.background = element_blank(),axis.ticks = element_blank(),
            legend.justification = c(1, 0),legend.position = c(0.6, 0.7),
            legend.direction = "horizontal")+
            guides(fill = guide_colorbar(barwidth = 7, barheight = 1,
                                         title.position = "top",
                                         title.hjust = 0.5))
```

Graph is Here!



Evaluation

There is a weak correlation on Gas Flaring section. According to the Turkish National Committee of the World Energy Council, the reason for the weakness of the effect of gas combustion on total carbon emissions is the carbon capture and storage systems used in the chimneys of the factories*.

*: World Energy Council Turkish National Committee (February 2018)

Evaluation

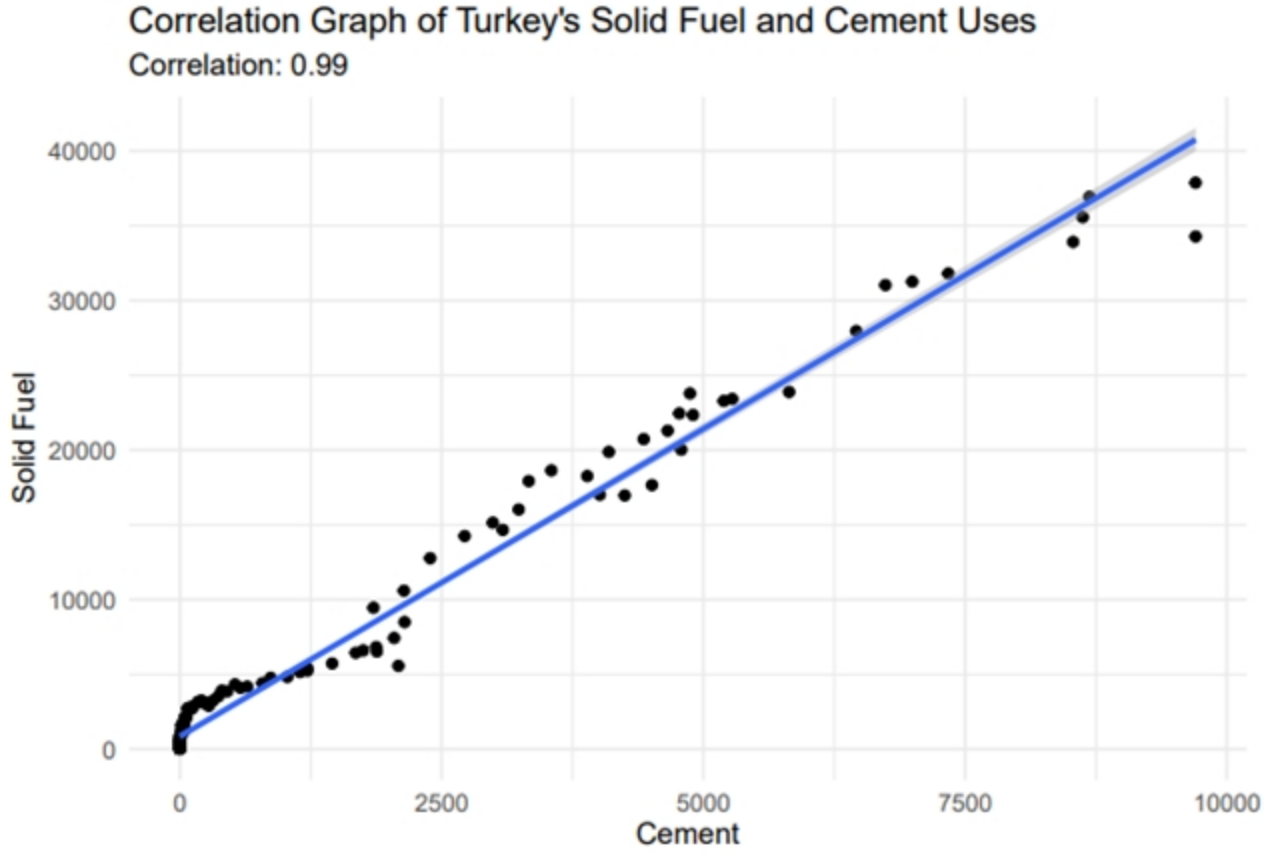
It has been stated by experts that the use of solid fuels as an alternative fuel for cement production has increased in recent years*.

*: Prof. Dr. H. Yılmaz ARUNTAS, Turkiye Cimento Sektorunde Alternatif Yakit Kullanimi

Cement-Solid Fuel Uses of Turkey

```
x = dataset$Cement[which(dataset["Country"] == "TURKEY")]
y = dataset$`Solid Fuel`[which(dataset["Country"] == "TURKEY")]

data <- data.frame(cement=x,solidfuel=y)
plot <- ggplot(data, aes(x=cement,y=solidfuel), col = "lightblue") +
        geom_point() +geom_smooth(formula = y ~ x, method = "lm")+
        ggtitle("Correlation Graph of Turkey's Solid Fuel and Cement Uses",
                subtitle = paste("Correlation:", round(cor(x, y), 2)))+
        xlab("Cement")+
        ylab("Solid Fuel")+
      theme(plot.title=element_text(color="black", size=12, face="bold",hjust=0.5),
        axis.title.x  =element_text(color="black", size=12, face="bold"),
        axis.title.y  =element_text(color="black", size=12, face="bold"))
plot + theme_minimal()
```

Cement-Solid Fuel Uses of Turkey



Comparison of Countries

```
topCountries <- function(added_cntry){
country <- c()
total <- c()
year <- c()

for (cntry in rev(unique(dataset$Country)))
    {country <- append(cntry,country)
    total <- append(
    as.numeric(sum(max(dataset$Total[which(dataset["Country"] == cntry)]),
                dataset$`Bunker Fuels`[which(dataset["Country"]==cntry)])),
               total) #So far, we have collected the data of the selected country.
                      #I want to note that, Bunker Fuels was not added to Total.
     year <- append(paste({min(dataset$Year[which(dataset["Country"] == cntry)])},
                          {max(dataset$Year[which(dataset["Country"] == cntry)])},
                          sep="-"),year)}
                          #In this section, we add in which year range the countries
```

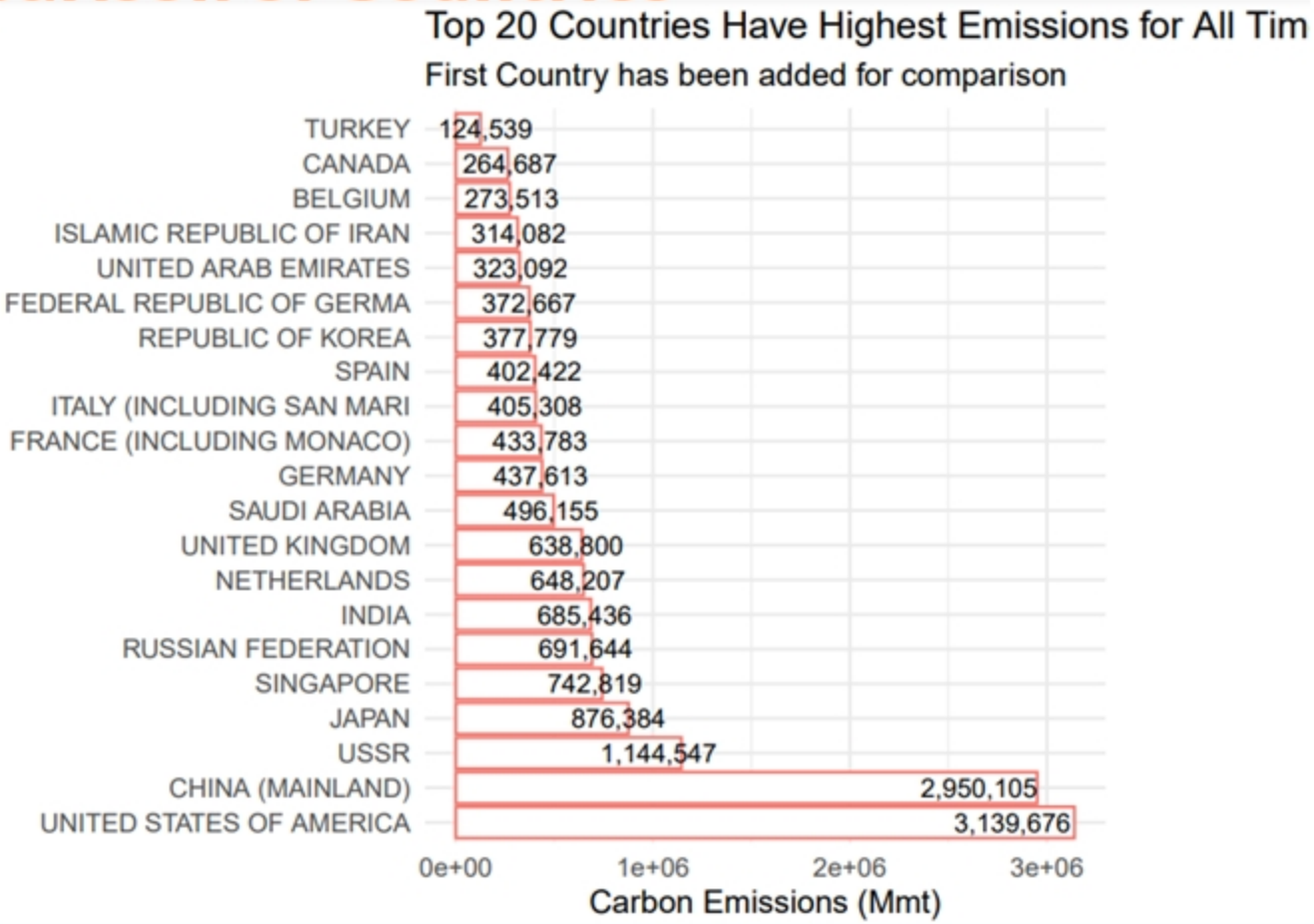
Comparison of Countries

```
data <- data.frame(coun =country, tot = total, yr=year)
data <- data[ with(data, order(tot,decreasing = TRUE)),]
rownames(data) <- NULL
data$coun <- substring(data$coun, 0, 25)
                    #We have limited country names to 25 characters

TURKEY <- data[which(data["coun"] == added_cntry):
                which(data["coun"] == added_cntry),]
data <- rbind(data[1:20,],TURKEY)
data <- data[ with(data, order(tot,decreasing = TRUE)),]
return(data)}        #This function gave the 20 countries with the highest values
                     #and Turkey, which is the reference country.
```

Comparison of Countries

```
bar <- ggplot(topCountries("TURKEY"),
              aes(x = tot, y = reorder(coun, -tot),color = "black")) +
      geom_col(stat = "identity",fill = "white")+
      ggtitle("Top 20 Countries Have Highest Emissions for All Time",
      subtitle = "First Country has been added for comparison")+
      xlab("Carbon Emissions (Mmt)")+  ylab("")+
      geom_text(aes(label=format(tot, big.mark = ",", scientific = FALSE),),
                size = 3,
                position = position_stack(vjust = 0.9),color = "black", size=12,
                face="bold")+
      theme(plot.title=element_text(color="black", size=12, face="bold"),
            axis.title.x  =element_text(color="black", size=12, face="bold"),
            legend.position="none")

bar + theme_minimal()
```

Comparison of Countries



Comparison of Countries

```
avg <- c()

avgOfTotal <- function(country){

  min_year <- min(dataset$Year[which(dataset["Country"] == country)])
  size <- length(unique(dataset$Country))
                      #We prepared the data to compare the total use of the country
  for(year in min_year:2014){
                      #We limited this to years for which the country had data.
    avg <- append(
      round(sum(dataset$Total[which(dataset["Year"] == year)])/size,2),avg)}

  avg <- data.frame(avgs = rev(avg),sz = rev(size))
  return(avg)}        #The dataset has been given for the years averaged.
```

Comparison of Countries

```
total_emission <- function(cntry,n){

  total <- dataset$Total[which(dataset["Country"] == cntry)]
                    #Two insignificant data have been found for Germany.
  if(cntry=="GERMANY"){
    total  <- total[total!=492]
    total  <- total[total!=353]}

  year_max <- max(dataset$Year[which(dataset["Country"] == cntry)])
  year_min <- min(dataset$Year[which(dataset["Country"] == cntry)])
  xlab     <- paste("Year",paste(year_min, year_max,sep="-"),sep = " ")
                    #Existing years have been kept for visualization.
  plot <- ggplot(data=data.frame(total), aes(x=1:length(total),y=total))+
      ggtitle(paste("Total CO2 Emissions Each Year Graph for",cntry,sep = " ")) +
      xlab(xlab)+
      ylab("Carbon Emissions (Mmt)")+
      theme(plot.title=element_text(color="black", size=9, face="bold",hjust=0.5),
            axis.title.x  =element_text(color="black", size=9, face="bold"),
            axis.title.y  =element_text(color="black", size=9, face="bold"))
```

Comparison of Countries

```
lbl4legend <- substr(cntry,1,3)

plot <- plot +     #Graph one. It's a total use of country has been choosen.
  geom_line(aes(y=total,group =1,color = lbl4legend))
plot <- plot +     #Graph two. It's an average of the rest of the countries.
  geom_line(data=avgOfTotal(cntry)[1:length(total),],
            aes(x=1:length(total),
                y=avgs,group =2,
                color = "Global Average"))
                   #Two graph will be combined. Look at below for second graph.
plot <- plot_grid(plot, lastnyears(cntry,n,year_max), nrow = 2, labels = "AUTO")
return(plot + theme_minimal())}
```

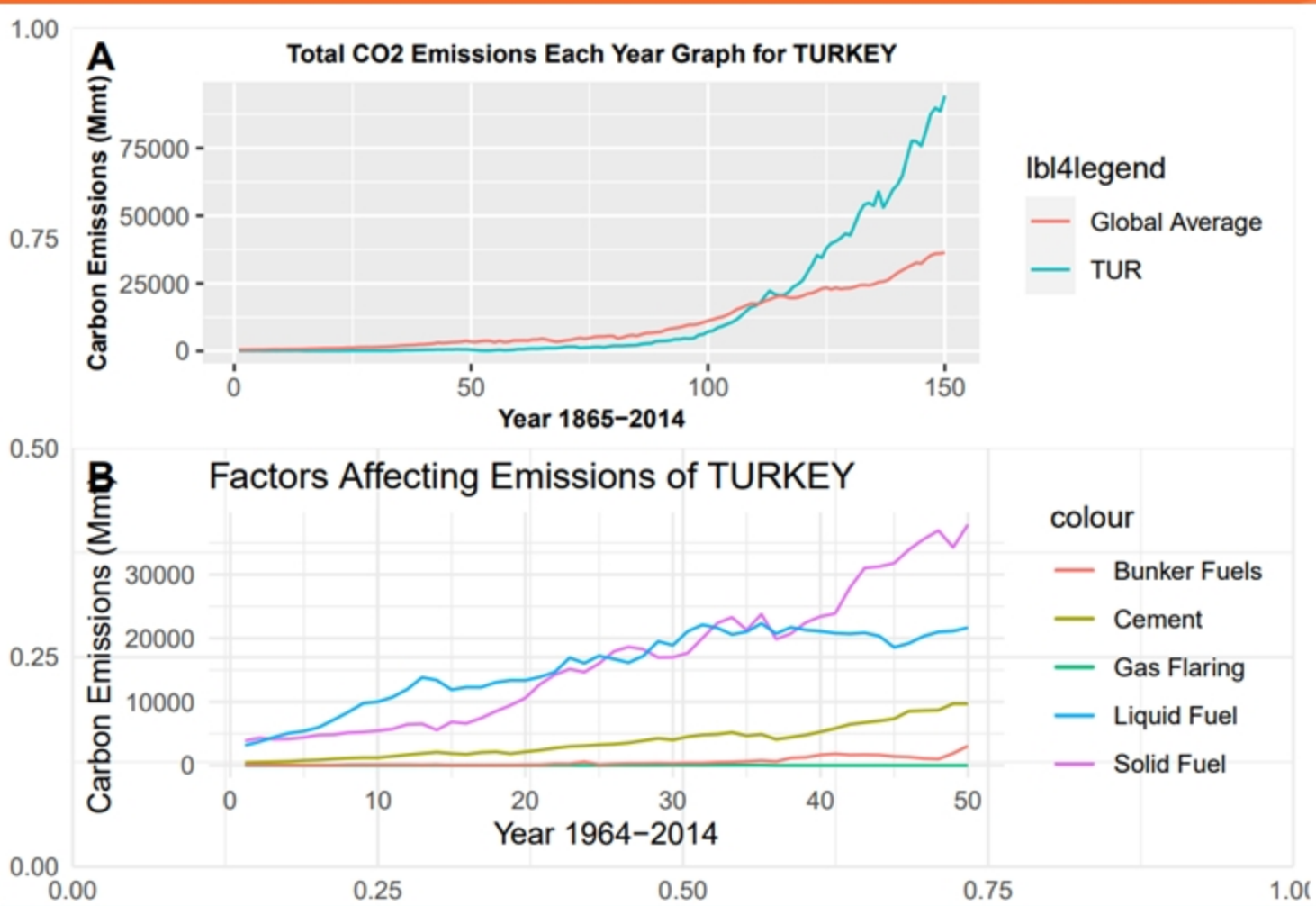
Comparison of Countries

```
lastnyears <- function(cntry,n,year_max){
                      #This function provides to specify detail of Countries that
COUNTRY <- cbind(     #has been choosen in last n years. N is an arbitrary number.
  dataset$`Solid Fuel`[which(dataset["Country"] == cntry)],
  dataset$`Liquid Fuel`[which(dataset["Country"] == cntry)],
  dataset$`Cement`[which(dataset["Country"] == cntry)],
  dataset$`Gas Flaring`[which(dataset["Country"] == cntry)],
  dataset$`Bunker Fuels`[which(dataset["Country"] == cntry)])

colnames(COUNTRY) = c("Solid Fuel",
                      "Liquid Fuel",
                      "Cement",
                      "Gas Flaring",
                      "Bunker Fuels")

COUNTRY <- data.frame(COUNTRY)
COUNTRY <- tail(COUNTRY, n =n)
                      #The tail() function provides thiٹs.
```

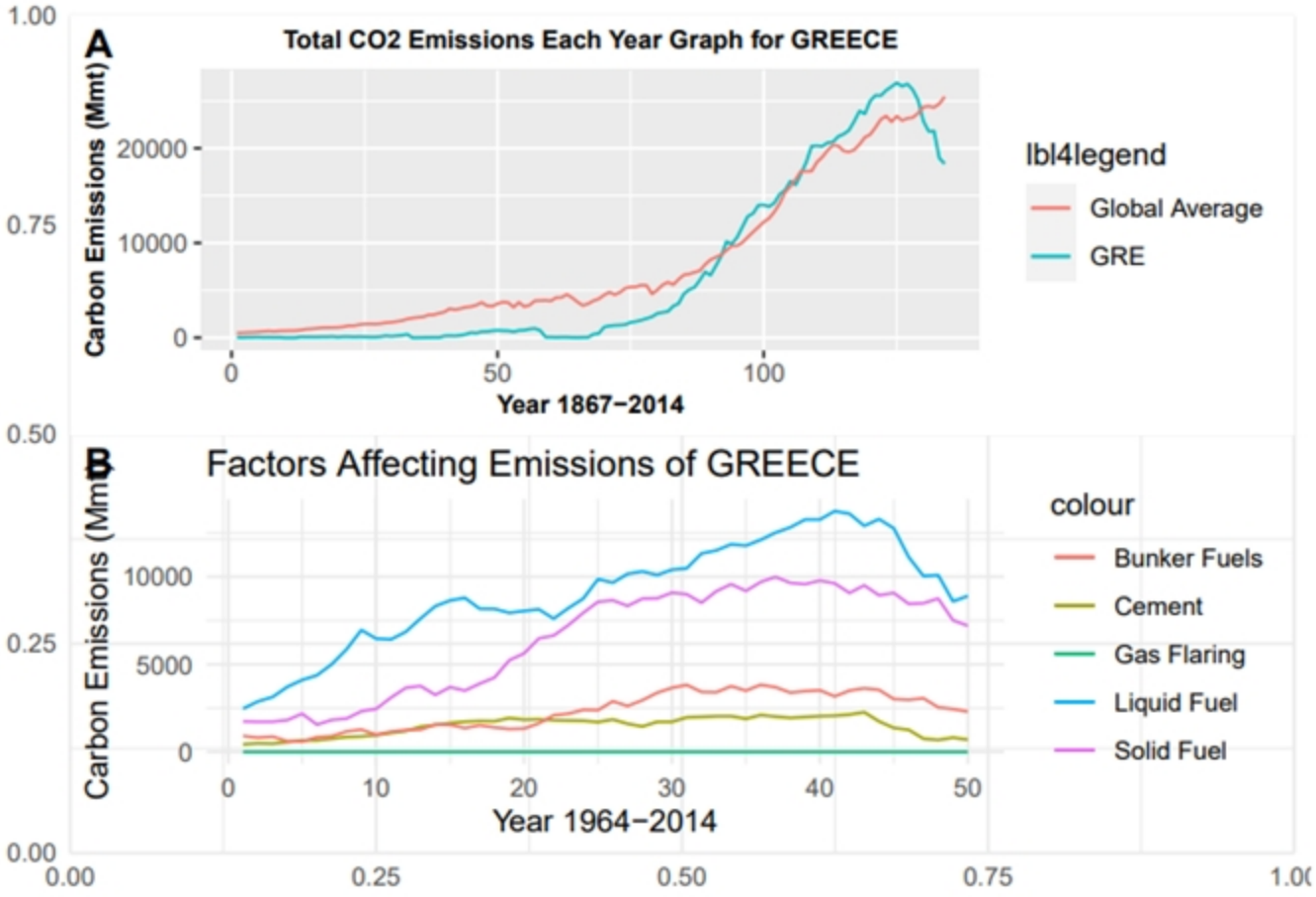
Comparison of Countries

```
xlab     <- paste("Year",paste(year_max-n, year_max,sep="-"),sep = " ")

plot <- ggplot(data=COUNTRY, aes(1:n))  +
    geom_line(aes(y = Solid.Fuel, color = "Solid Fuel"))+
    geom_line(aes(y = Liquid.Fuel, color = "Liquid Fuel"))+
    geom_line(aes(y = Cement, color = "Cement"))+
    geom_line(aes(y = Gas.Flaring, color = "Gas Flaring"))+
    geom_line(aes(y = Bunker.Fuels, color = "Bunker Fuels"))+
    ggtitle(paste("Factors Affecting Emissions of",cntry,sep = " ")) +
    xlab(xlab)+ ylab("Carbon Emissions (Mmt)")+
    theme(plot.title=element_text(color="black", size=9, face="bold",hjust=0.5),
          axis.title.x  =element_text(color="black", size=9, face="bold"),
          axis.title.y  =element_text(color="black", size=9, face="bold"))

return(plot+ theme_minimal())}
```

```
total_emission("TURKEY",50)
```


A
Total CO2 Emissions Each Year Graph for TURKEY
Carbon Emissions (Mmt)
75000
50000
25000
0
0
50
100
150
Year 1865−2014
lbl4legend
Global Average
TUR
B
Factors Affecting Emissions of TURKEY
Carbon Emissions (Mmt)
30000
20000
10000
0
0
10
20
30
40
50
Year 1964−2014
colour
Bunker Fuels
Cement
Gas Flaring
Liquid Fuel
Solid Fuel
1.00
0.75
0.50
0.25
0.00
0.00
0.25
0.50
0.75

```
total_emission("GREECE",50)
```

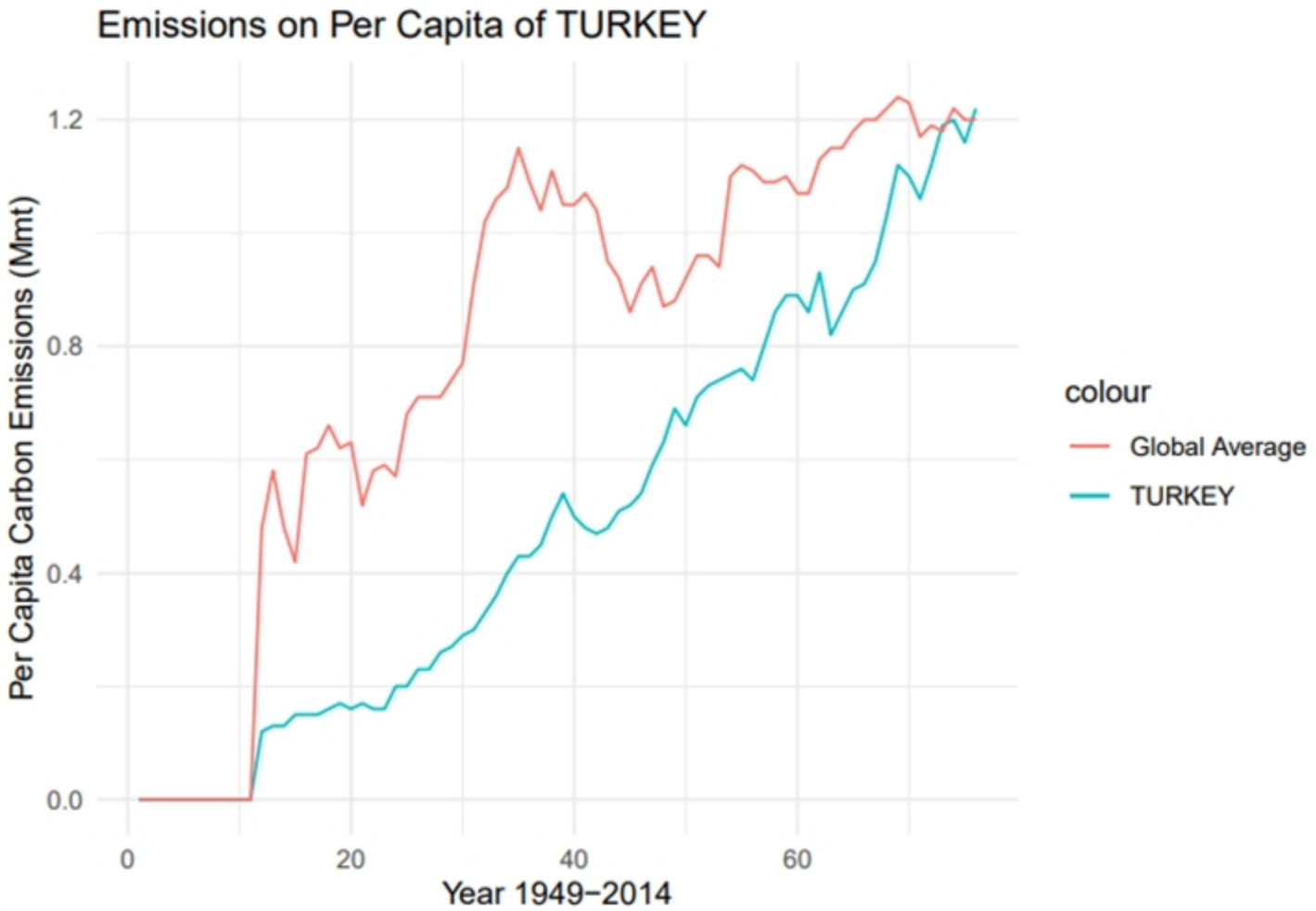


Comparison of Countries

```
avg <- c()

avgOfPerCapita <- function(lowestYear){

  size <- length(unique(dataset$Country))

  for(year in lowestYear:2014){
                    #We limited this to years for which the country had data.
    avg <- append(
      round(sum(dataset$`Per Capita`[which(dataset["Year"] == year)])/size,2),avg)}
  lowestYear
  avg <- data.frame(avgs = rev(avg),sz = rev(size))

  return(avg)}        #The dataset has been given for the years averaged.
```

Comparison of Countries

```
perCapita <- function(country){#Emission data per capita began to be
  data <-data.frame(            #taken after 1949.
  c1=dataset$`Per Capita`[which(dataset["Country"] == country)][75:150],
  c2=dataset$Year[which(dataset["Country"] == country)][75:150],
  c3=avgOfPerCapita(1865)$avgs[75:150])

  xlab<- paste("Year",paste(1949, 2014,sep="-"),sep = " ")
    plot <- ggplot(data)+geom_line(aes(x=1:76,y=c1, color = "TURKEY"))+
          geom_line(aes(x=1:76,y=c3,group =2, color = "Global Average"))+
          ggtitle(paste("Emissions on Per Capita of",country,sep = " " )) +
          xlab(xlab)+ ylab("Per Capita Carbon Emissions (Mmt)")+
          theme(plot.title=element_text(
            color="black", size=9, face="bold",hjust=0.5),
          axis.title.x =element_text(color="black", size=9, face="bold"),
          axis.title.y =element_text(color="black", size=9, face="bold"))
return(plot + theme_minimal())}

perCapita("TURKEY")
```


Emissions on Per Capita of TURKEY
Per Capita Carbon Emissions (Mmt)
1.2
0.8
0.4
0.0
0
20
40
60
Year 1949−2014
colour
Global Average
TURKEY

We have seen that emissions per capita are below the global average. But this increased trend is higher than the global average in the recent years.

Consequently, We deduce that although the main fuels used are similar in geographically close countries, the usage trend may be different. Also, while the world average of emissions per capita has passed a stagnant trend, it has been observed that Turkey is in an increasing trend.

Source of Dataset

Boden, T.A., G. Marland, and R.J. Andres. 2013. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2013

THANKS FOR LISTENING!

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