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INTRODUCTION

The Ministry of Power and Renewable Energy is actively involved in research projects designed to address current issues with power generation to fulfil the nation's rising demand. Enhancing energy efficiency in building cooling systems is a major area of concentration to lower residential and commercial power usage, which accounts for a sizeable amount of the nation's overall electricity demand. To accomplish these aims, a dataset called "energy_efficiency_data.csv" and an associated data dictionary has been made available to investigate any potential relationships between building cooling and other building structural variables connected to building forms. R, R-studio, QGIS and PostgreSQL will be used to complete these tasks.

The results of the first investigation will be used in the final phase of this project to create accurate statistical models that capture the relationships between building cooling and related structural elements. These models use tools such as R, R-studio, and R-commander and will be informed by the given data set. Additional critical analysis will be done on models produced in Sri Lanka's unique energy consumption patterns and building architecture.

The task also comprises creating a digitally enhanced informational area map that highlights the probable locations for solar power plant construction as well as other pertinent elements like structures, roads, trees, and woods. Utilising readily accessible geospatial technologies like QGIS and open-layer plugins, the digitization process will produce a map that will be examined to see how well solar energy would be able to handle Sri Lanka's energy sector's problems.

While developing a PostgreSQL geospatial database named "SLPetrolium-2023" to store information on petrol and diesel usage. Shapefiles and data of district-level statistics including the number of sheds and mean, and standard deviation of petrol and diesel usage are stored in the database. It also creates thematic maps to gain an understanding of the distribution of the use of petroleum products. The project also includes identifying potential places to produce renewable energy as determined by the Sri Lanka Sustainable Energy Authority.

The development of a map showing potential locations for a regional research centre for renewable energy in the Kandy region marks the completion of the job. Along with

a rigorous analysis of the appropriateness of the chosen location, the map shows the total number of nearby structures, the space occupied by these buildings, and the overall amount of suitable territory.

Chapter 1

Task A

To solve the problems related to demand-driven power generation, the Ministry of Power and Renewable Energy is looking for new solutions through regional and international research. A key area of focus is improving the energy efficiency of building cooling systems, which are essential to reducing home and business energy use. Thus, the data set "energy_efficiency_data.csv" and R-studio or R-studio Cloud tools are used. To accomplish this task, potential relationships between building cooling and structural factors will be analyzed. According to the data set provided, it is classified as categorical and continues to be. Thus, the following analysis was conducted using continuous factors.

Continue	**Categorical**
Relative Compactness	Orientation
Surface Area	Glazing Area Distribution
Wall Area	-
Roof Area	-
Overall Height	-
Glazing Area	-
Heating Load	-
Cooling Load	-

Add libraries.

When performing this analysis, the required libraries are first imported. They are Rcmdr, Gggplot2, GridExtra(Millán-Martínez and Oller, 2020).

```
# Load the necessary libraries
library(Rcmdr) # Load the R Commander package for a graphical user interface
library(ggplot2)# Load the ggplot2 package for creating data visualizations
library(gridExtra)# Load the gridExtra package for arranging and customizing plots
```

Load the data set.

Second, the energy_efficiency_data.csv data set is read. Accordingly, the factors of that dataset are Relative Compactness, Surface Area, Wall Area, Roof Area, Overall Height, Orientation, Glazing Area, Glazing Area Distribution, Heating Load, Cooling Load.

```
# Read the data set
unclean.data <- read.csv("energy_efficiency_data.csv")

# View the first few rows of the dataset
head(data)
```

```
> # View the first few rows of the dataset
> head(data)
  Relative_Compactness Surface_Area Wall_Area Roof_Area Overall_Height Orientation Glazing_Area Glazing_Area_Distribution
1                 0.98        514.5     294.0    110.25              7           2            0                         0
2                 0.98        514.5     294.0    110.25              7           3            0                         0
3                 0.98        514.5     294.0    110.25              7           4            0                         0
4                 0.98        514.5     294.0    110.25              7           5            0                         0
5                 0.90        563.5     318.5    122.50              7           2            0                         0
6                 0.90        563.5     318.5    122.50              7           3            0                         0
  Heating_Load Cooling_Load
1        15.55        21.33
2        15.55        21.33
3        15.55        21.33
4        15.55        21.33
5        20.84        28.28
6        21.46        25.38
>
```

Data preprocessing

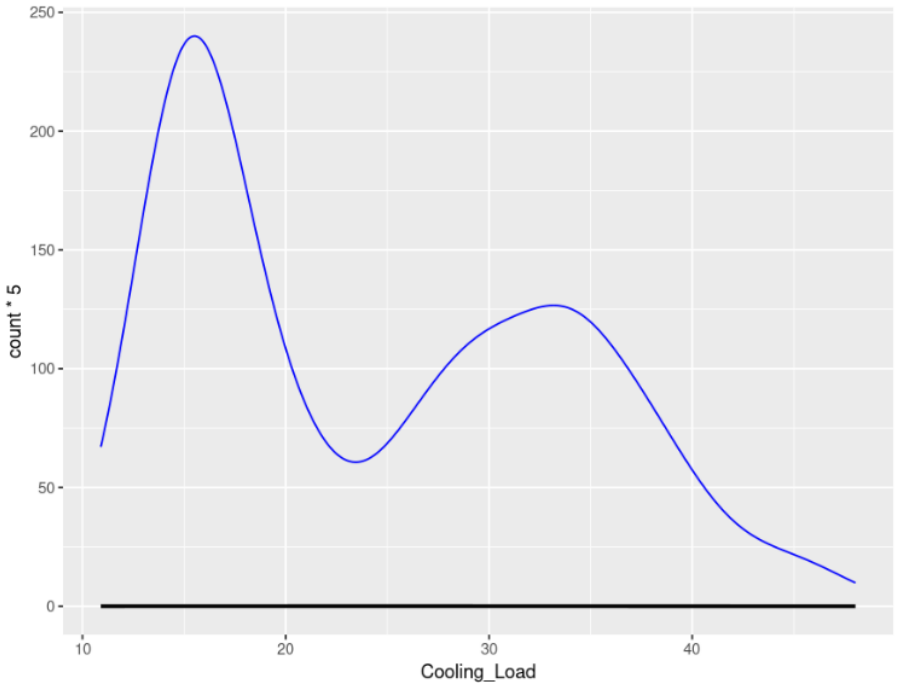
As the next step, the data preprocessing part is done. Accordingly, removing the null value of the dataset, the summary of the dataset is obtained. According to this summary, min, max, median, mean have been determined. Also, it has been checked again whether there are null values in the dataset.

```
#data pre-processing
data <- na.omit(unclean.data)

# Summary statistics for numerical variables
summary(data)

# Check for missing values
sapply(data, function(x) sum(is.na(x)))
```

```
> #data pre-processing
> data <- na.omit(unclean.data)
> summary(data)
 Relative_Compactness  Surface_Area     Wall_Area       Roof_Area     Overall_Height  Orientation    Glazing_Area
 Min.   :0.6200       Min.   :514.5   Min.   :245.0   Min.   :110.2   Min.   :3.50   Min.   :2.00   Min.   :0.0000
 1st Qu.:0.6825       1st Qu.:606.4   1st Qu.:294.0   1st Qu.:140.9   1st Qu.:3.50   1st Qu.:2.75   1st Qu.:0.1000
 Median :0.7500       Median :673.8   Median :318.5   Median :183.8   Median :5.25   Median :3.50   Median :0.2500
 Mean   :0.7642       Mean   :671.7   Mean   :318.5   Mean   :176.6   Mean   :5.25   Mean   :3.50   Mean   :0.2344
 3rd Qu.:0.8300       3rd Qu.:741.1   3rd Qu.:343.0   3rd Qu.:220.5   3rd Qu.:7.00   3rd Qu.:4.25   3rd Qu.:0.4000
 Max.   :0.9800       Max.   :808.5   Max.   :416.5   Max.   :220.5   Max.   :7.00   Max.   :5.00   Max.   :0.4000
 Glazing_Area_Distribution  Heating_Load    Cooling_Load
 Min.   :0.000             Min.   : 6.01   Min.   :10.90
 1st Qu.:1.750             1st Qu.:12.99   1st Qu.:15.62
 Median :3.000             Median :18.95   Median :22.08
 Mean   :2.812             Mean   :22.31   Mean   :24.59
 3rd Qu.:4.000             3rd Qu.:31.67   3rd Qu.:33.13
 Max.   :5.000             Max.   :43.10   Max.   :48.03
> sapply(data, function(x) sum(is.na(x)))
     Relative_Compactness               Surface_Area                 Wall_Area                 Roof_Area
                        0                          0                         0                         0
           Overall_Height               Orientation             Glazing_Area Glazing_Area_Distribution
                        0                          0                         0                         0
             Heating_Load              Cooling_Load
                        0                          0
```

Bell curves for Cooling data distributions

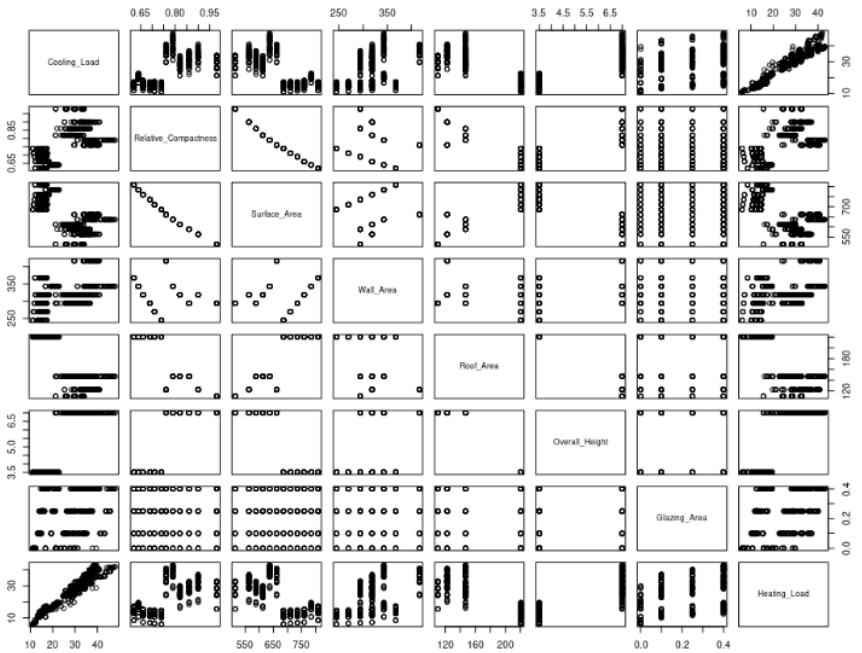
The Bell curve chart below illustrates the data distribution by cooling load in the data set. Thus, the peak of the curve at the centre represents the mean or average value of the data set. Furthermore, the spread or dispersion of the data in this dataset is expressed in terms of the standard deviation. Thus, this is referred to as a Multimodal Distribution.



Scatterplot matrix

The following scatterplot shows the structural factors of a building. According to those factors, the relationship of the structural factors changes according to the chilling load of the building. Thus, a positive relationship between the cooling load and the heating load is expressed. Also, there is a negative relationship between Surface Area and Relative Compactness, and between Wall Area and Relative Compactness. Another positive relationship exists between Surface Area and Wall Area.

```
# Create scatterplot matrix
pairs(data[, c("Cooling_Load", "Relative_Compactness", "Surface_Area", "Wall_Area", "Roof_Area",
               "Overall_Height", "Glazing_Area", "Heating_Load")],
      main = "Scatterplot Matrix")
```



Full dataset Summary of lanner regression

According to continues value, a model should be developed to examine the relationship between a building's cooling load and other variables. The model prepared for that is described below. According to the summary statics obtained according to that model, the relationship is shown as described above.

```
# Simple linear regression
lm_model <- lm(Cooling_Load ~ Relative_Compactness + Surface_Area + Wall_Area +
                 Roof_Area + Overall_Height + Glazing_Area + Heating_Load, data = data)

# Summary of the regression model
summary(lm_model)
```

```
Call:
lm(formula = Cooling_Load ~ Relative_Compactness + Surface_Area +
    Wall_Area + Roof_Area + Overall_Height + Glazing_Area + Heating_Load,
    data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-4.7918 -1.1500 -0.1510  0.9017  7.5642

Coefficients: (1 not defined because of singularities)
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          25.289819  12.875614   1.964 0.049875 *
Relative_Compactness -15.159815   7.049381  -2.151 0.031829 *
Surface_Area          -0.013280   0.011600  -1.145 0.252656
Wall_Area             -0.007544   0.004677  -1.613 0.107144
Roof_Area                   NA         NA      NA       NA
Overall_Height         0.702701   0.247163   2.843 0.004588 **
Glazing_Area          -2.734094   0.724517  -3.774 0.000173 ***
Heating_Load           0.858800   0.024099  35.636  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.96 on 761 degrees of freedom
Multiple R-squared:  0.9579,    Adjusted R-squared:  0.9575
F-statistic:  2883 on 6 and 761 DF,  p-value: < 2.2e-16
```

Chapter 2

Task B

2.1. Regression Analyst

A statistical model has been prepared for the relationship through the above task. Accordingly, in this task, the creation of a statistical model as well as the related Hypothesis Statement and summary statics have been used. This will make an analysis.(Ansari and Nassif, 2022)

2.1.1.1. Hypothesis Statement

H0	There is no significant relationship between the Cooling load and the Heating Load of the building
H1	There is a significant relationship between the Cooling load and the Heating Load of the building

Significance level (x) = 0.05

Confidence level = 95%

2.1.1.2. Learner model

```
> lm_model_H <- lm(Cooling_Load ~ Heating_Load, data = data)
> lm_model_H

Call:
lm(formula = Cooling_Load ~ Heating_Load, data = data)

Coefficients:
 (Intercept)  Heating_Load
      4.0636        0.9201
```

Y data$Cooling_Load = 4.06 + 0.92 X data$Heating_Load

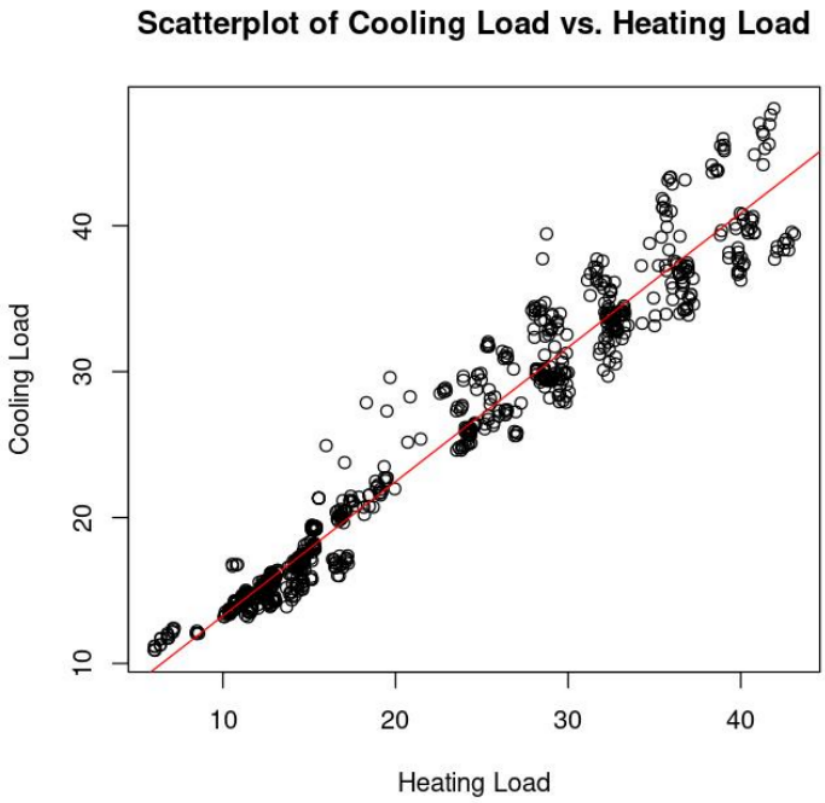
2.1.1.3. Summary Statistic for lm () Function

```
> #Heating_Load
> lm_model_H <- lm(Cooling_Load ~ Heating_Load, data = data)
> summary(lm_model_H)

Call:
lm(formula = Cooling_Load ~ Heating_Load, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-5.0849 -1.1504 -0.1884  0.6713  8.9244

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   4.06361    0.18212   22.31   <2e-16 ***
Heating_Load  0.92007    0.00744  123.67   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.079 on 766 degrees of freedom
Multiple R-squared:  0.9523,    Adjusted R-squared:  0.9522
F-statistic: 1.529e+04 on 1 and 766 DF,  p-value: < 2.2e-16

>
```

Decision: p-value = 2.2e-16 <x = 0.05> Reject H0

An incredibly small p-value of 2.2e-16 for the relationship between Cooling Load and heating load has a strong and statistically significant correlation. At a significance level of 0.05, which is commonly used in hypothesis testing, we have significant evidence to reject the null hypothesis. Therefore, there is a significant relationship between cooling load and heating load.

2.1.1.4. Scatter Plot



2.1.2. Cooling Load and Relative Compactness

2.1.2.1. Hypothesis Statement

H0	There is no significant relationship between the Cooling load and the Relative Compactness of the building
H1	There is a significant relationship between the Cooling load and the Relative Compactness of the building

Significance level (x) = 0.05

Confidence level = 95%

2.1.2.2. Learner model

```
> lm_model_R <- lm(Cooling_Load ~ Relative_Compactness, data = data)
> lm_model_R

Call:
lm(formula = Cooling_Load ~ Relative_Compactness, data = data)

Coefficients:
         (Intercept)  Relative_Compactness
              -19.01                 57.05
```

Y data$Cooling_Load = -19.0 + 57.05 *X* data$ Relative_Compactness

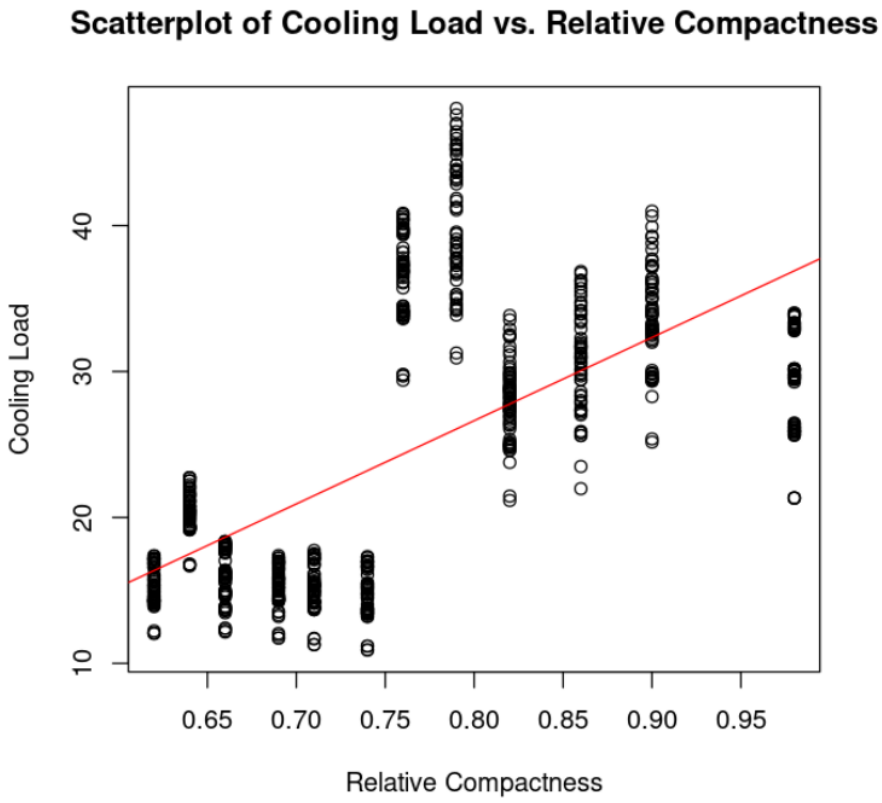
2.1.2.3. Summary Statistic for lm () Function

```
> #Relative_Compactness
> lm_model_R <- lm(Cooling_Load ~ Relative_Compactness, data = data)
> summary(lm_model_R)

Call:
lm(formula = Cooling_Load ~ Relative_Compactness, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-15.571  -5.632  -1.233   3.379  21.968

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         -19.008      1.938  -9.809   <2e-16 ***
Relative_Compactness  57.051      2.512  22.710   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7.359 on 766 degrees of freedom
Multiple R-squared:  0.4024,    Adjusted R-squared:  0.4016
F-statistic: 515.8 on 1 and 766 DF,  p-value: < 2.2e-16

>
```

Decision: p-value = 2.2e-16 <x = 0.05> Reject H0

An incredibly small p-value of 2.2e-16 for the relationship between cooling load and relative compactness has a strong and statistically significant correlation. At a significance level of 0.05, which is commonly used in hypothesis testing, we have significant evidence to reject the null hypothesis. Therefore, there is a significant relationship between relative compactness and heating load.

Scatter Plot



2.1.3. Cooling Load and Overall Height

2.1.3.1. Hypothesis Statement

H0	There is no significant relationship between the Cooling load and the Overall Height of the building
H1	There is a significant relationship between the Cooling load and the Overall Height of the building

Significance level (x) = 0.05

Confidence level = 95%

2.1.3.2. Learner model

```
> lm_model_O <- lm(Cooling_Load ~ Overall_Height, data = data)
> lm_model_O

Call:
lm(formula = Cooling_Load ~ Overall_Height, data = data)

Coefficients:
   (Intercept)  Overall_Height
       -0.9612          4.8665
```

Y data$Cooling_Load = -0.96 + 4.86 *X* data$Overall _Height

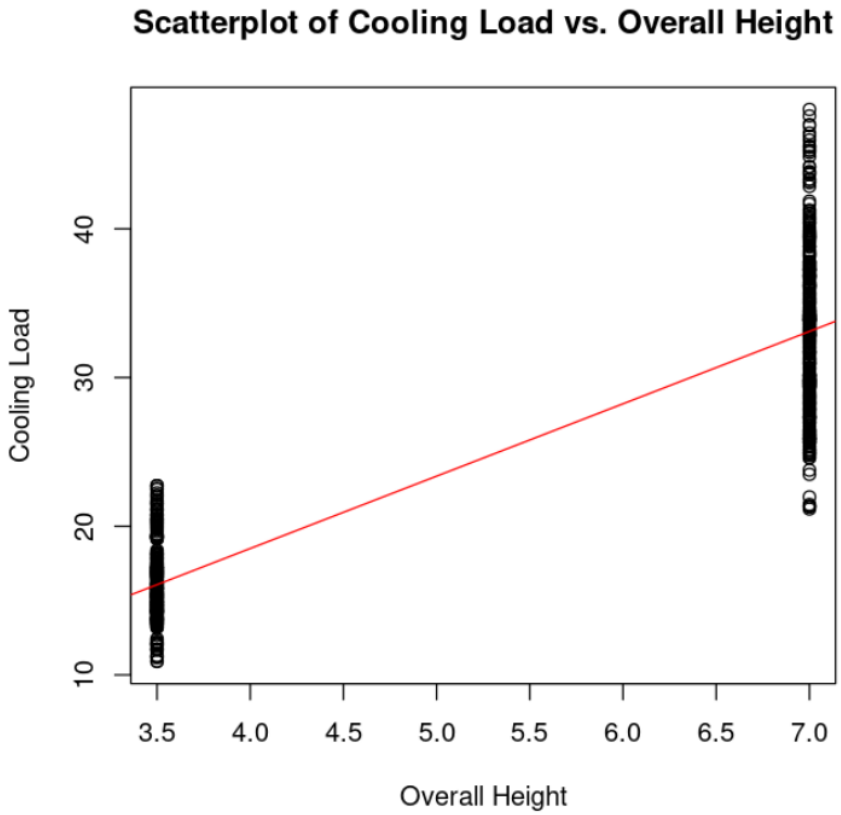
2.1.3.3. Summary Statistic for lm () Function

```
> #Overall_Height
> lm_model_O <- lm(Cooling_Load ~ Overall_Height, data = data)
> summary(lm_model_O)

Call:
lm(formula = Cooling_Load ~ Overall_Height, data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-11.9441  -2.3539  -0.2664   2.0386  14.9259

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    -0.96122    0.48283  -1.991   0.0469 *
Overall_Height  4.86647    0.08725  55.777   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.231 on 766 degrees of freedom
Multiple R-squared:  0.8024,    Adjusted R-squared:  0.8022
F-statistic:  3111 on 1 and 766 DF,  p-value: < 2.2e-16
```

Decision: p-value = 2.2e-16 <x = 0.05> Reject H0

There is a strong and statistically significant correlation with an incredibly small p-value of 2.2e-16 for the relationship between Cooling Load and Overall Height. At a significance level of 0.05, which is commonly used in hypothesis testing, we have significant evidence to reject the null hypothesis. Therefore, there is a significant relationship between cooling load and Overall Height.

2.1.3.4. Scatter plot



2.1.4. Cooling Load and Glazing Area

2.1.4.1. Hypothesis Statement

H0	There is no significant relationship between the Cooling load and the Glazing Area of the building
H1	There is a significant relationship between the Cooling load and the Glazing Area of the building

Significance level (x) = 0.05

Confidence level = 95%

2.1.4.2. Learner model

```
> lm_model_G <- lm(Cooling_Load ~ Glazing_Area, data = data)
> lm_model_G

Call:
lm(formula = Cooling_Load ~ Glazing_Area, data = data)

Coefficients:
 (Intercept)  Glazing_Area
       21.11         14.82
```

Y data$Cooling_Load = 21.11 + 14.81 *X* data$Glazing_Area

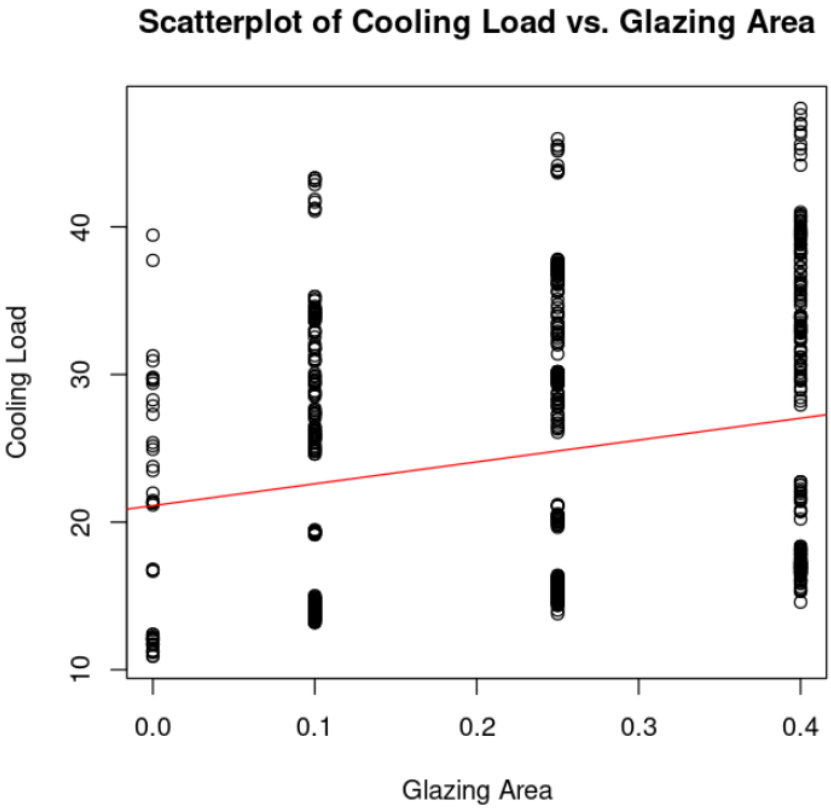
2.1.4.3. Summary Statistic for lm () Function

```
> #Glazing_Area
> lm_model_G <- lm(Cooling_Load ~ Glazing_Area, data = data)
> summary(lm_model_G)

Call:
lm(formula = Cooling_Load ~ Glazing_Area, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-12.462  -9.049  -1.536   8.127  21.151

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   21.1148     0.6803  31.036  < 2e-16 ***
Glazing_Area  14.8180     2.5240   5.871 6.46e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.312 on 766 degrees of freedom
Multiple R-squared:  0.04306,   Adjusted R-squared:  0.04181
F-statistic: 34.47 on 1 and 766 DF,  p-value: 6.457e-09
```

Decision: p-value = 2.2e-16 <x = 0.05> Reject H0

An incredibly small p-value of 2.2e-16 for the relationship between cooling load and glazing area has a strong and statistically significant correlation. At a significance level of 0.05, which is commonly used in hypothesis testing, we have significant evidence to reject the null hypothesis. Therefore, there is a significant relationship between cooling load and glacier area.

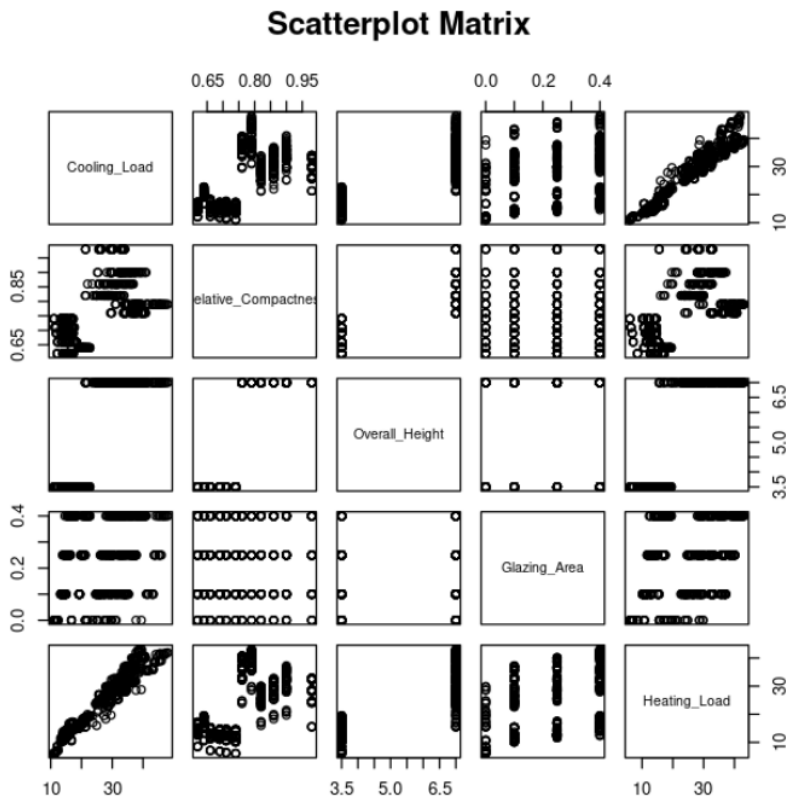
2.1.4.4. Scatter plot



2.1.4.5. Full model Scatter plot

The figure below shows the scatter plot of building factors with relationships.

```
# scatterplot matrix
pairs(data[, c("Cooling_Load", "Relative_Compactness",
               "Overall_Height", "Glazing_Area", "Heating_Load")],
      main = "Scatterplot Matrix")
```


Scatterplot Matrix
Cooling_Load
elative_Compactnes
Overall_Height
Glazing_Area
Heating_Load
0.65 0.80 0.95
0.0 0.2 0.4
10 30
0.65 0.85
3.5 5.0 6.5
0.0 0.2 0.4
10 30
3.5 5.0 6.5
10 30

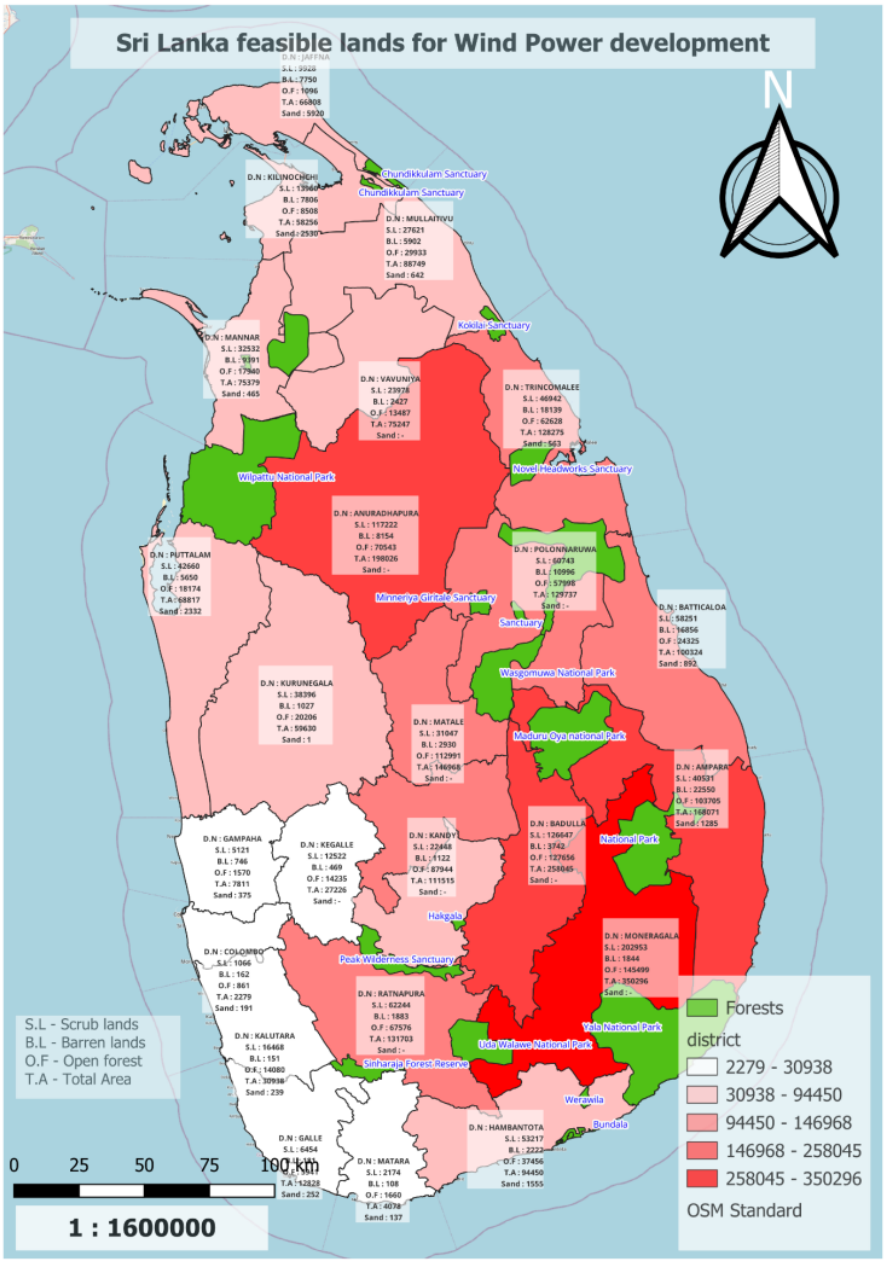
Chapter 3

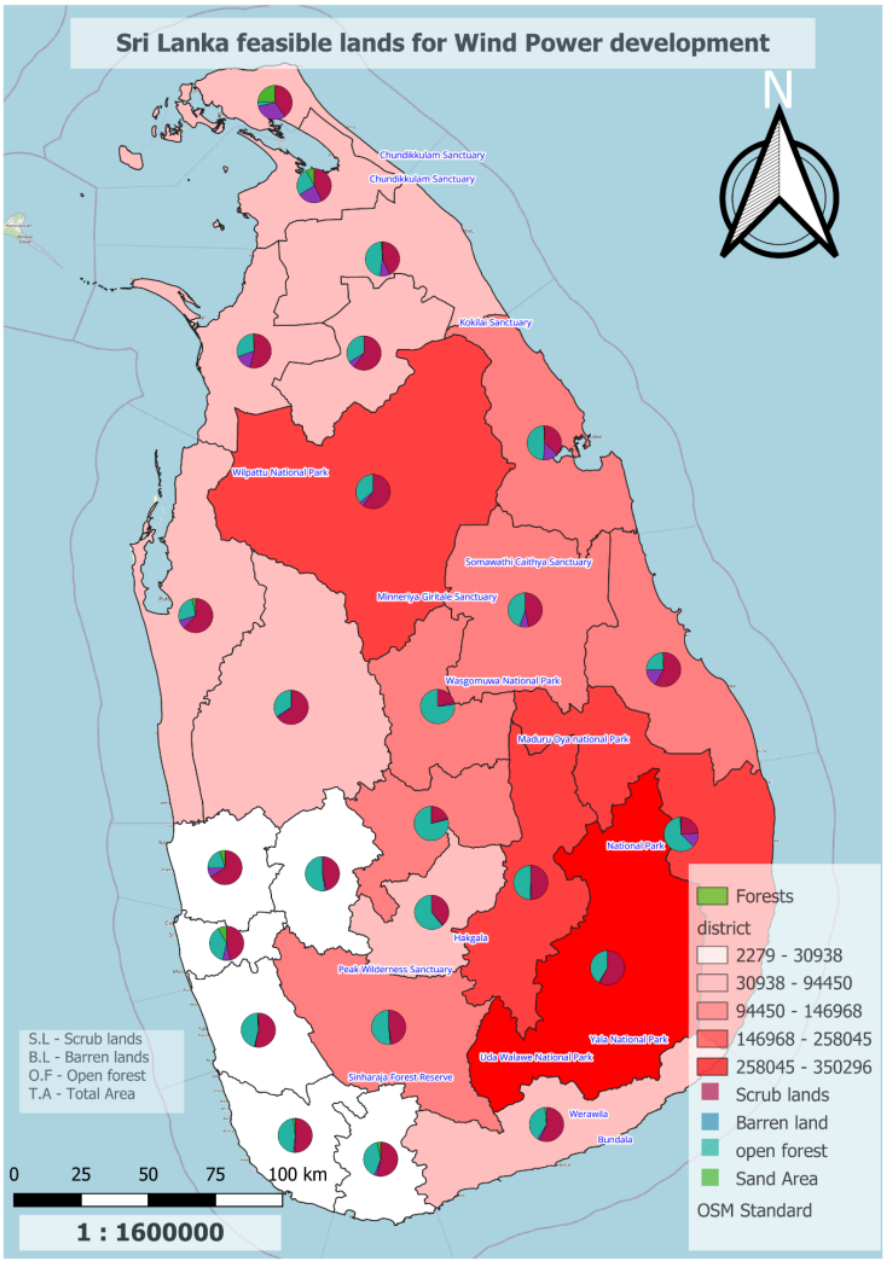
Task C

In recent years, the urgent need to mitigate climate change and reduce the use of fossil fuels has emerged, and wind power has emerged as a promising and environmentally friendly alternative to generate electricity. The "Renewable Energy Development Plan 2021-2026", published by the Sri Lanka Solar Energy Authority, outlines a strategic roadmap for expanding the use of wind energy resources across the country. Accordingly, create "SLWindPowerLand_21_23.csv" data set using table 7.1: Land available for wind power data in Renewable-Energy-Resource-Development-Plan.pdf provided by Sri Lanka Sustainable Energy Authority(Rodrigo, n.d.). This CSV file is shown below.

	A	B	C	D	E	F	G	H	I	J	K
1	District	SCRBA	BRRNA	FRSOA	SANDA	HOMSA	SPRSA	GRSLA	PLMRA	CCNTA	Total
2	AMPARA	40531	22550	103705	1285	-	-	-	-	-	168071
3	ANURADHAPURA	117222	8154	70543	-	961	1143	-	-	3	198026
4	BADULLA	126647	3742	127656	-	-	-	-	-	-	258045
5	BATTICALOA	58251	16856	24325	892	-	-	-	-	-	100324
6	COLOMBO	1066	162	861	191	-	-	-	-	-	2279
7	GALLE	6454	181	5941	252	-	-	-	-	-	12828
8	GAMPAHA	5121	746	1570	375	-	-	-	-	-	7811
9	HAMBANTOTA	53217	2222	37456	1555	-	-	-	-	-	94450
10	JAFFNA	9928	7750	1096	5920	34778	3313	2449	701	874	66808
11	KALUTARA	16468	151	14080	239	-	-	-	-	-	30938
12	KANDY	22448	1122	87944	-	-	-	-	-	-	111515
13	KEGALLE	12522	469	14235	-	-	-	-	-	-	27226
14	KILINOCHCHI	13960	7806	8508	2530	17516	5742	21	469	1705	58256
15	KURUNEGALA	38396	1027	20206	1			-	-	-	59630
16	MANNAR	32532	9391	17940	465	8715	4523	227	737	849	75379
17	MATALE	31047	2930	112991	-	-	-	-	-	-	146968
18	MATARA	2174	108	1660	137	-	-	-	-	-	4078
19	MONERAGALA	202953	1844	145499	-	-	-	-	-	-	350296
20	MULLAITIVU	27621	5902	29933	642	16716	6505	402	-	1029	88749
21	NUWARA ELIYA	33582	555	52807	-	-	-	-	-	-	86944
22	POLONNARUWA	60743	10996	57998	-	-	-	-	-	-	129737
23	PUTTALAM	42660	5650	18174	2332	-	-	-	-	-	68817
24	RATNAPURA	62244	1883	67576	-	-	-	-	-	-	131703
25	TRINCOMALEE	46942	18139	62628	563	-	4	-	-	-	128275
26	VAVUNIYA	23978	2427	13487	-	21268	12934	1044	-	108	75247
27											

To create the "Sri Lanka Feasible Land for Wind Energy Development" map, the total size of the district, total capacity, total estimated energy is used as required data column. According to the "SLWindPowerLand_21_23.csv" file above, this map is shown in the figure below (Figure 7:1).


Sri Lanka feasible lands for Wind Power development
N
S.L - Scrub lands
B.L - Barren lands
O.F - Open forest
T.A - Total Area
0 25 50 75 100 Km
1 : 1600000
Forests
district
2279 - 30938
30938 - 94450
94450 - 146968
146968 - 258045
258045 - 350296
OSM Standard



As shown in the picture above, it has been mapped with the aim of identifying suitable areas for wind power development. Thus, district wise the total area is divided into scrub land, barren land, open forest, and sand areas. Thus, on this map, the area that represents most of the total land area is shown in dark red, and the color decreases as the geometry decreases. The area shown in white indicates the lowest area. Also, on

this map all the forests of the island appear green, and these forests are denoted by name.

Figure 36-37 grouped scrubland, wasteland, open forest, and sand areas according to the map. Monaragala, Anuradhapura, Ampara, Badulla districts have the largest area but no sandy areas. The total area of these areas is more than 146968 hectares. Also, between 2279 and 30938 hectares, Gampaha, Colombo, Kalutara, Galle, Matara represent the least areas in total area. Thus, considering the Total land area according to Provinces, the following table shows.

Province	Total Area (ha)
North Province	364439
Uva Province	608341
North Central Province	327763
East Province	396670
Western Province	41028
Central Province	345427
Southern Province	111356
Northwestern Province	128447
Sabaragamuwa Province	158929

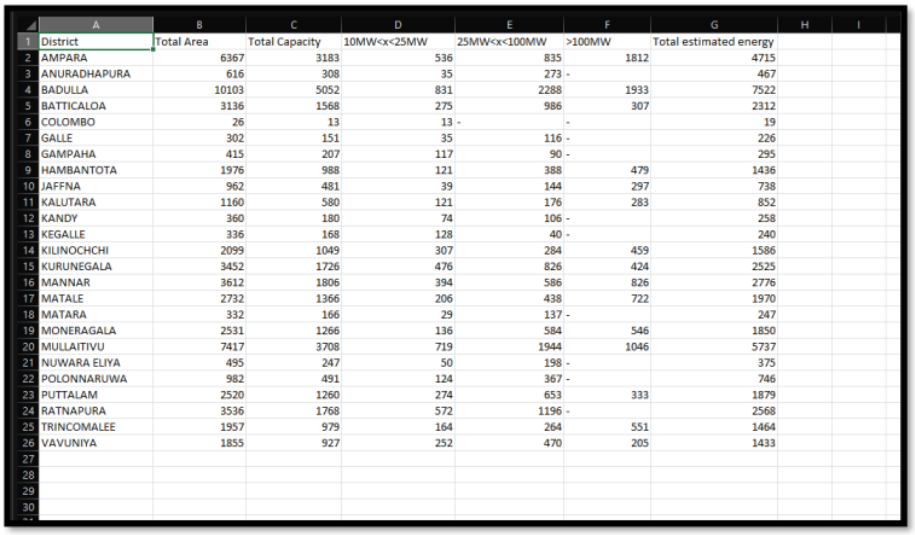
When compared provincially, Monaragala, Uva province belonging to Badulla shows the largest amount of land. Also, it can be understood from the above table that Eastern Province is the second largest region.

From this given data, it is not possible to determine a suitable location for wind power generation. But according to these data, Monaragala and Anuradhapura districts can be concluded as suitable areas.

Chapter 4

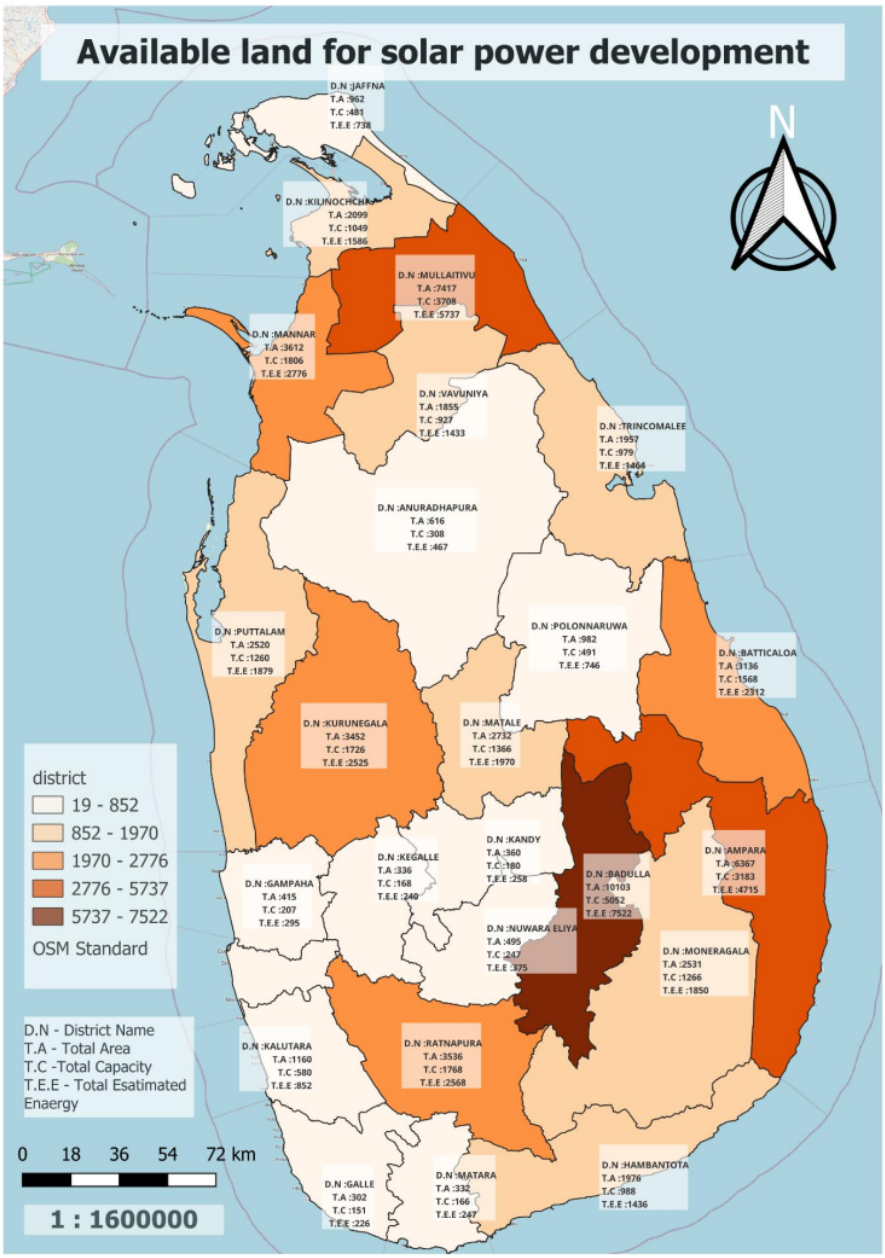
Task D

Most of the countries in the world are currently using solar power to generate renewable energy. As Sri Lanka is a country close to the equator, Sri Lanka gets constant sunlight. Maps are created according to table 7.4 of "Renewable-Energy-Resource-Development-Plan.pdf" published by Sri Lanka Renewable Energy Authority to find potential land for solar energy development. A CSV file is created using District Name, Total Area (ha), Total Capacity (MW) and Total estimated energy (GWh) to create this map. Below is an image of the relevant data set.



District	Total Area	Total Capacity	10MW<x<25MW	25MW<x<100MW	>100MW	Total estimated energy
AMPARA	6367	3183	536	835	1812	4715
ANURADHAPURA	616	308	35	273	-	467
BADULLA	10103	5052	831	2288	1933	7522
BATTICALOA	3136	1568	275	986	307	2312
COLOMBO	26	13	13	-	-	19
GALLE	302	151	35	116	-	226
GAMPAHA	415	207	117	90	-	295
HAMBANTOTA	1976	988	121	388	479	1436
JAFFNA	962	481	39	144	297	738
KALUTARA	1160	580	121	176	283	852
KANDY	360	180	74	106	-	258
KEGALLE	336	168	128	40	-	240
KILINOCHCHI	2099	1049	307	284	459	1586
KURUNEGALA	3452	1726	476	826	424	2525
MANNAR	3612	1806	394	586	826	2776
MATALE	2732	1366	206	438	722	1970
MATARA	332	166	29	137	-	247
MONERAGALA	2531	1266	136	584	546	1850
MULLAITIVU	7417	3708	719	1944	1046	5737
NUWARA ELIYA	495	247	50	198	-	375
POLONNARUWA	982	491	124	367	-	746
PUTTALAM	2520	1260	274	653	333	1879
RATNAPURA	3536	1768	572	1196	-	2568
TRINCOMALEE	1957	979	164	264	551	1464
VAVUNIYA	1855	927	252	470	205	1433

This dataset captures Sri Lanka's varied energy landscape, including changes in energy generating capacity. While some districts include a mix of smaller and medium-sized plants, some have a considerable presence of bigger energy-producing facilities. The data shows each district's contribution to the nation's overall energy supply as well as its potential for energy production.



Shown above (Figure 7.1) is the map of land available for solar energy development. As shown in this map, the area of highest total estimated energy is shown in dark brown. Also, the bold color represents the range of total estimated energy between 2776 and 5737. Areas with low total estimated energy are represented in white. This map is described below.

By studying this map, it is identified that most of the estimated total energy can be generated from Badulla district. Its total area is about 10103 hectares. The total capacity of this district is 5052 MW. According to the data presented by the Sri Lanka Renewable Energy Authority, the estimated total energy in this area is identified as 7522GWh. According to this map the total estimated energy in the range of 277GWh6 and 5737GWh as TEE in Ampara and Mullaitivu districts is 4715GWh and 5737GWh. Thus, the second highest TEE value is shown in Mullaitivu district. Also, the TEE value of Mannar, Kurunegala, Batticaloa, and Ratnapura districts are in the range of 1970GWh and 2776GWh. Gampaha, Kalutara, Galle, Kegalle, Kandy, Nuwara Eliya, Anuradhapura and Jaffna districts are the districts with the lowest estimated energy. Its TEE value is less than 852GWh areas.

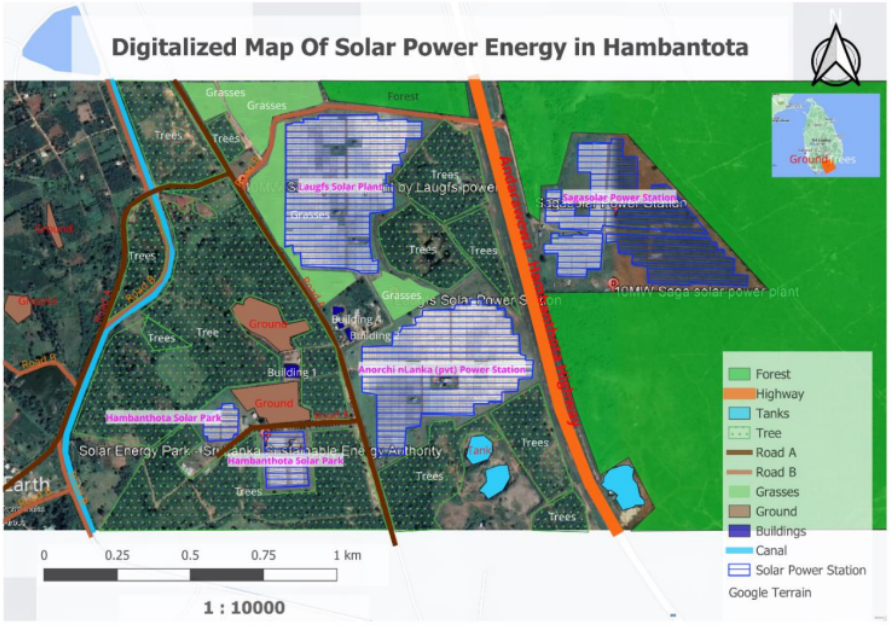
Province	Total Estimated Energy (GWh)
North Province	12270
Uva Province	9372
North Central Province	1213
East Province	8491
Western Province	1166
Central Province	2603
Southern Province	1909
Northwestern Province	4404
Sabaragamuwa Province	2808

Northern province can be considered as the highest TEE by province. It is shown as 12270GWh in the above table. The Western Province can be introduced as the province where the minimum amount of GWh can be obtained. Thus, Badulla district is the area with the highest TEE availability, which is different from other provinces. Understanding these processes can provide insight into Sri Lanka's energy planning and distribution systems, and support decision-making to ensure a reliable and sustainable energy supply across many sectors of the country.

Chapter 5

Task E

At a time when sustainable energy solutions are critical, using solar energy is still a realistic option. Solar power plants and their suburbs are shown in Google image digitized. Thus, with the help of QGIS(Kranjac et al., 2018), the map should include the solar plants, buildings, roads, trees and forests. Also, coordinate reference system as WGS84-EPSG4326 is used for map development. Thus, the image created with the help of QGIS is provided below.



Solar energy, especially as a renewable energy source, provides a critical solution to the island's energy challenges. This map uses Google Earth, Google Maps, and QGIS plugins to digitize a solar plant and its surroundings. Accordingly, separate shapefiles are created for the solar plant, buildings, roads, trees, and ponds in this map. This map aims to assess the potential of solar energy to solve the island's energy problems. And according to my map, Andarawawa to Hambantota highway is depicted in orange colour. Also, Solar power station has been built on both sides of this highway. Talking about solar plant, Laughs solar plants, Anorchi Lanka, Sagasolr, and Hambantota solar park have created power station. From the direction shown in this map, the forest appears in green colour from the east. Studying this map has shown many tree locations.

Also, canal and Tanks are represented in blue colour. And the brown colour represents the ground area.

According to this map, it is suitable for the construction of solar power station in Sri Lanka. Also, there are rural areas where electricity cannot be provided. Solar power station can be built as a solution to those areas. Also, at present, hydroelectric power plants are used to supply electricity to Sri Lanka, but due to the lack of rainfall, it is difficult to supply electricity. As a solution to that, by deploying solar power stations nationwide, the Sri Lanka Sustainable Energy Authority will not have to face difficult situations.

Chapter 6

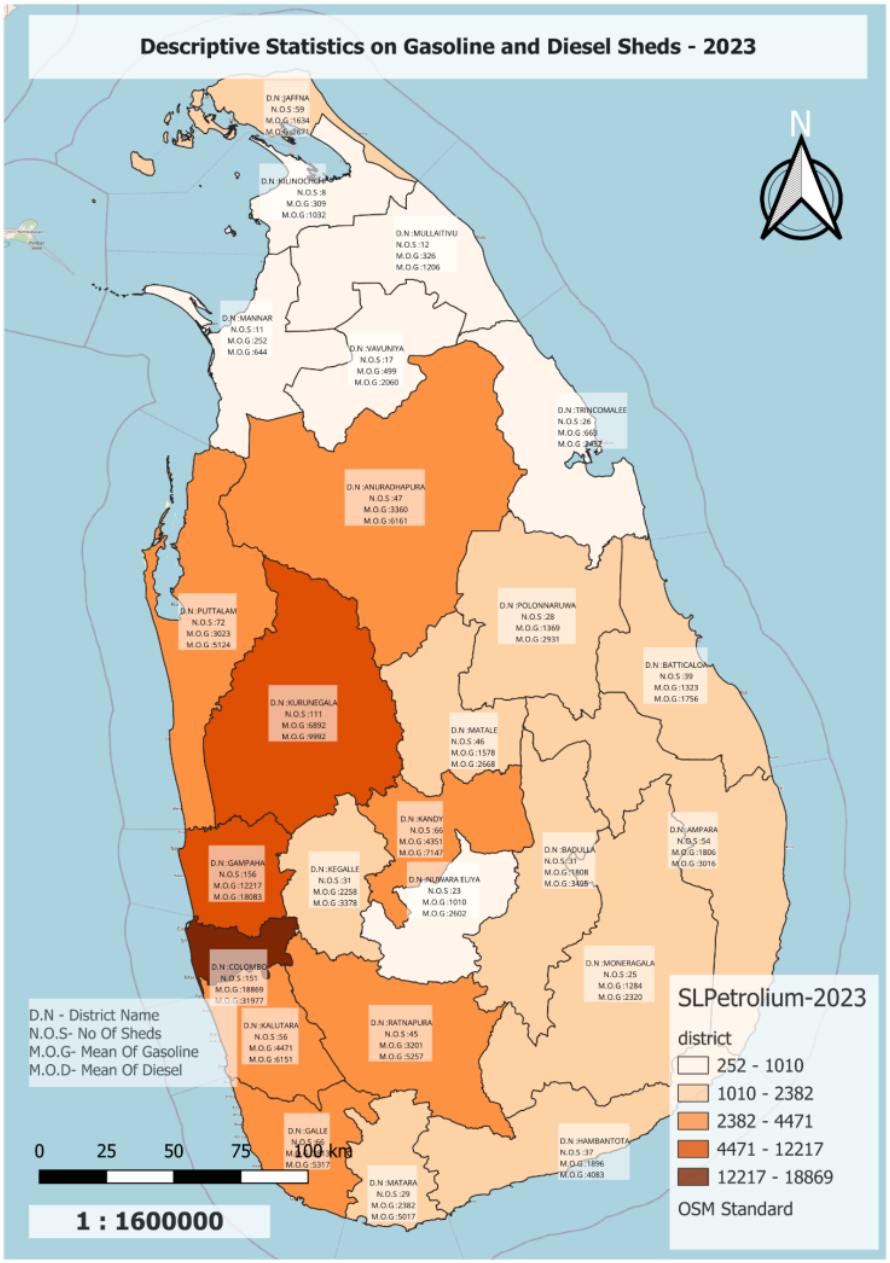
Task F

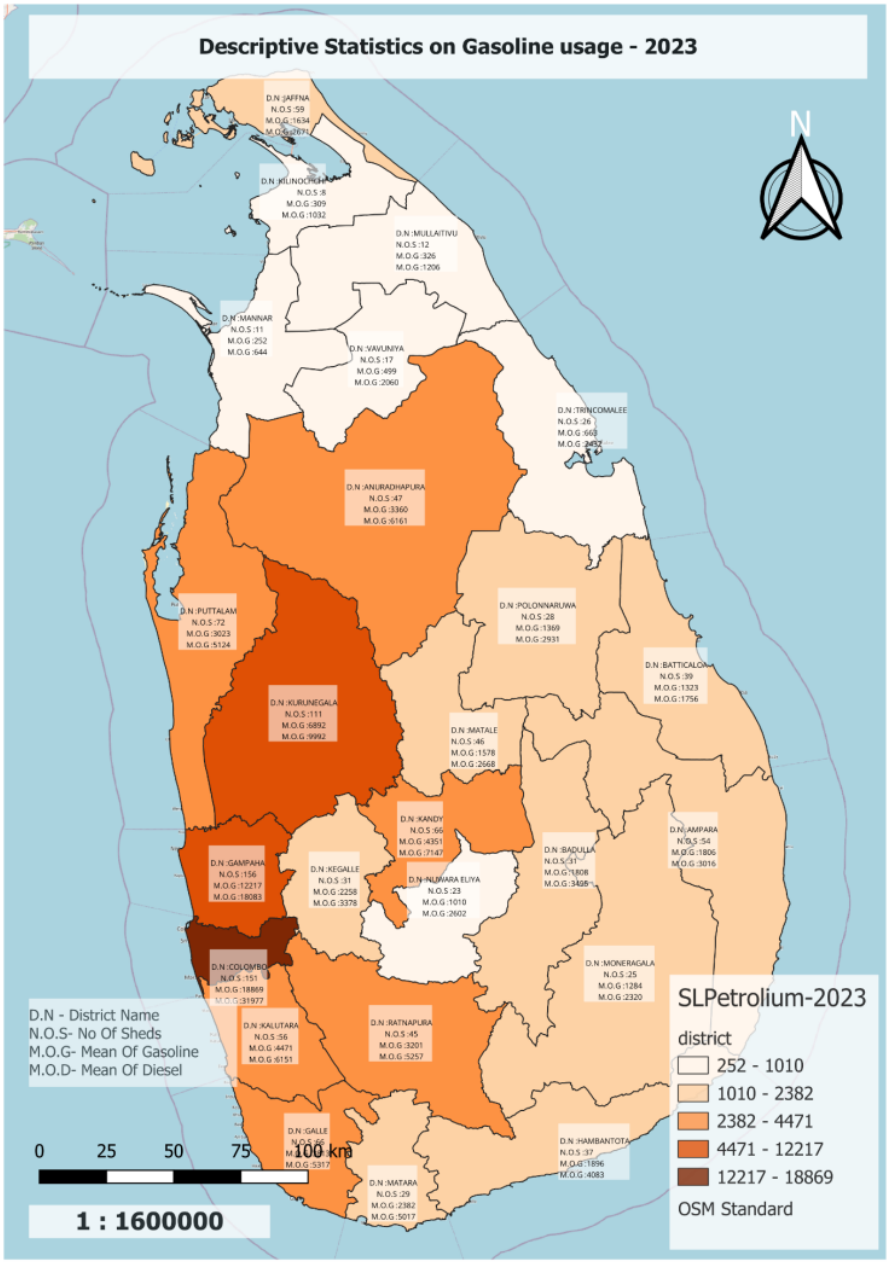
In this chapter a detailed analysis is done using the thematic map according to the data file provided by Sri Lanka Sustainable Energy Authority. To accomplish this task, a table named SLGOVSCHOOLS.2019 was created under this database and the required data was entered. Table: 5-03 provided in the file "Disaggregation-of-Petroluem-Fuel-Use-2021-May-29.PDF" was used to create this data file. Accordingly, in the CSV file prepared previously, District Name, No of Sheds, Mean and SD of Gasoline, Mean and SD of Diesel I saved the data as SLPetrolium-2023. A screenshot of this file (image :7.1) is shown. According to this data file, a PostgreSQL database named "SLPetrolium-2023" was created using PgAdmin software.

	A	B	C	D	E	F	G
1	District	No_Of_Sheds	Gasoline_SD	Gasoline_Mean	Diesel_SD	Diesel_Mean	
2	COLOMBO	151	796	18869	11438	31977	
3	GAMPAHA	156	528	12217	4746	18083	
4	KALUTARA	56	217	4471	1422	6151	
5	KANDY	66	180	4351	2236	7147	
6	MATALE	46	81	1578	930	2668	
7	NUWARA ELIYA	23	71	1010	1175	2602	
8	GALLE	66	185	3813	1317	5317	
9	MATARA	29	170	2382	2131	5017	
10	HAMBANTOTA	37	112	1896	1690	4083	
11	JAFFNA	59	97	1634	826	2671	
12	MANNAR	11	23	252	317	644	
13	VAVUNIYA	17	37	499	1156	2060	
14	MULLAITIVU	12	25	326	688	1206	
15	KILINOCHCHI	8	20	309	573	1032	
16	BATTICALOA	39	114	1323	660	1756	
17	AMPARA	54	118	1806	1080	3016	
18	TRINCOMALEE	26	418	663	1169	2432	
19	KURUNEGALA	111	303	6892	2684	9992	
20	PUTTALAM	72	122	3023	1260	5124	
21	ANURADHAPURA	47	183	3360	2199	6161	
22	POLONNARUWA	28	404	1369	1260	2931	
23	BADULLA	31	115	1808	1343	3495	
24	MONERAGALA	25	106	1284	903	2320	
25	RATNAPURA	45	169	3201	1706	5257	
26	KEGALLE	31	134	2258	922	3378	
27							

SLPetrolium-2023

Below is the thematic map showing the number of sheds according to the data set added to PostgreSQL named "SLPetrolium-2023".


Descriptive Statistics on Gasoline and Diesel Sheds - 2023
N
D.N :JAFFNA
N.O.S :59
M.O.G :1634
D.N :KILINOCHCHI
N.O.S :8
M.O.G :309
M.O.G :1032
D.N :MULLAITIVU
N.O.S :12
M.O.G :326
M.O.G :1206
D.N :MANNAR
N.O.S :11
M.O.G :252
M.O.G :644
D.N :VAVUNIYA
N.O.S :17
M.O.G :499
M.O.G :2060
D.N :TRINCOMALEE
N.O.S :26
M.O.G :663
M.O.G :2452
D.N :ANURADHAPURA
N.O.S :47
M.O.G :3360
M.O.G :6161
D.N :PUTTALAM
N.O.S :72
M.O.G :3023
M.O.G :5124
D.N :POLONNARUWA
N.O.S :28
M.O.G :1369
M.O.G :2931
D.N :BATTICALOA
N.O.S :39
M.O.G :1323
M.O.G :1756
D.N :KURUNEGALA
N.O.S :111
M.O.G :6892
M.O.G :9992
D.N :MATALE
N.O.S :46
M.O.G :1578
M.O.G :2668
D.N :KANDY
N.O.S :66
M.O.G :4351
M.O.G :7147
D.N :AMPARA
N.O.S :54
M.O.G :1806
M.O.G :3016
D.N :GAMPAHA
N.O.S :156
M.O.G :12217
M.O.G :18083
D.N :KEGALLE
N.O.S :31
M.O.G :2258
M.O.G :3378
D.N :NUWARA ELIYA
N.O.S :23
M.O.G :1010
M.O.G :2602
D.N :BADULLA
N.O.S :51
M.O.G :1808
M.O.G :3408
D.N :COLOMBO
N.O.S :151
M.O.G :18869
D.N :MONERAGALA
N.O.S :25
M.O.G :1284
M.O.G :2320
D.N :KALUTARA
N.O.S :56
M.O.G :4471
M.O.G :6151
D.N :RATNAPURA
N.O.S :45
M.O.G :3201
M.O.G :5257
D.N :GALLE
N.O.S :66
M.O.G :5317
D.N :HAMBANTOTA
N.O.S :37
M.O.G :1896
M.O.G :4083
D.N :MATARA
N.O.S :29
M.O.G :2382
M.O.G :5017
D.N - District Name
N.O.S- No Of Sheds
M.O.G- Mean Of Gasoline
M.O.D- Mean Of Diesel
0 25 50 75 100 km
1 : 1600000
SLPetrolium-2023
district
252 - 1010
1010 - 2382
2382 - 4471
4471 - 12217
12217 - 18869
OSM Standard



The above thematic map illustrates information about the District Name, No of Sheds, Mean and SD of Gasoline, and Mean and SD of Diesel. And by studying this map, the Gampaha district has the highest number of sheds. It is represented by N.O.S- 156. And 111 and 156 ranges include Gampaha as well as Colombo district. It has 151 sheds. Thus the "Descriptive Statistics on Gasoline Usage- 2023" map shows that Colombo

Districts have the highest Mean of Gasoline. From this it can be concluded that the consumption of Gasoline and Diesel is higher in Colombo districts compared to Gampaha districts. Also, considering the use of Gasoline, Kurunegala has the third highest use and shows 9992 as the mean of its use value.

However, the largest number of sheds in the Northern Province is in the Jaffna district. It has 59 sheds. Compared to other Northern Province districts (Mutative, Kilinochchi, Vavuniya and Mannar) the number of sheds in these districts is very low and their values are 12, 8, 17, 11 respectively. And a look at the petrol consumption map shows a huge lack of work for the districts in the western provinces.

Using this database and map, stakeholders, decision makers and energy planners can gain important insights into regional patterns of petroleum use across districts. These data appear to be critical for developing focused initiatives to improve sustainable energy use and resource allocation.

Chapter 7

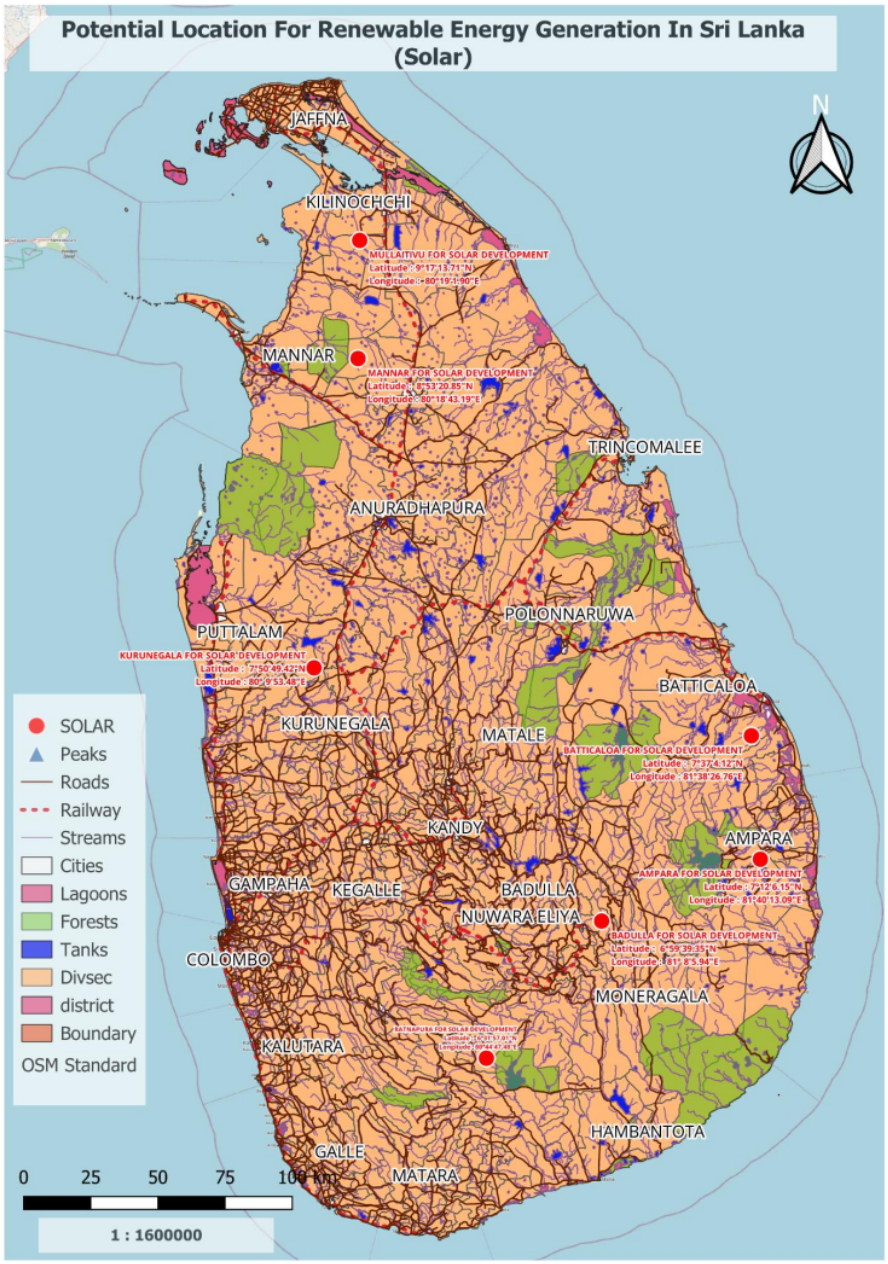
Task G

Sri Lanka, a tropical island in the Indian Ocean, is gradually recognizing the importance of sustainable energy sources for its development. As the world grapples with environmental challenges, the Sri Lanka Renewable Energy Authority strategically identifies viable sites for renewable energy generation across the island. It creates a map. Also, information like location labels, district names, latitudes, and longitude are displayed on the map. Google Earth Pro is used to set the latitude and longitude of the correct location. This obtained location is saved as KMZ File. This obtained KMZ file is used to visualize the map using QGIS. As shown in the map below (Figure 1.1), the location where renewable energy such as Solar, Wind, and Biomass can be established in Sri Lanka is shown.

The above map shows the location for the renewable energy plant and the points used in red mark the suitable locations for the construction of the solar plant. Blue points indicate areas suitable for wind power development and green points indicate areas suitable for biofuel production. The light green areas on this map are obviously forested areas.

As shown in the maps in the above Tasks, suitable areas for Solar and Wind power station development in Sri Lanka have been shown. Also, the data in the PDF file provided by the Sri Lanka Sustainable Energy Authority has been studied and appropriate areas have been mapped according to that map. As previously mentioned, Mannar, Mullaitivu, Kurunegala, Batticaloa, Badulla, and Ratnapura districts have been shown in red as the areas to develop the Solar project, and the Latitude and Longitude information related to those districts has been visualized. While selecting the location for solar project development, the district has been studied using Google Earth Pro and vacant land areas and government lands have been selected in that area. Also, two locations have been provided from Hambantota, Ratnapura, Mathele, Puttalam, Jaffna and Mannar and Anuradhapura districts as areas for the Wind power development project. In selecting these land areas, the factors of environmental impact, infrastructure, nearby schools, and minimum areas of hospitals were carefully considered. Also, Hambantota, Monaragala, Badulla, Batticaloa, and Polonnaruwa are clearly shown on the district map as suitable areas for Biomass projects. Also, Latitude and Longitude information has been visualized in the areas suitable for construction. The map below (Figure 1, Figure 2, Figure 3) shows separately Solar, Wind, and Biomass.

Ultimately, this mapping will enable the Renewable Energy Authority to select viable sites and increase renewable energy generation in Sri Lanka.


Potential Location For Renewable Energy Generation In Sri Lanka (Solar)
N
JAFFNA
KILINOCHCHI
MULLAITIVU FOR SOLAR DEVELOPMENT
Latitude : 9°17'13.71"N
Longitude : 80°19'1.90"E
MANNAR
MANNAR FOR SOLAR DEVELOPMENT
Latitude : 8°53'20.85"N
Longitude : 80°18'43.19"E
TRINCOMALEE
ANURADHAPURA
POLONNARUWA
PUTTALAM
KURUNEGALA FOR SOLAR DEVELOPMENT
Latitude : 7°50'49.42"N
Longitude : 80°0'53.46"E
BATTICALOA
KURUNEGALA
MATALE
BATTICALOA FOR SOLAR DEVELOPMENT
Latitude : 7°37'4.12"N
Longitude : 81°38'26.76"E
KANDY
AMPARA
AMPARA FOR SOLAR DEVELOPMENT
Latitude : 7°12'6.15"N
Longitude : 81°40'13.09"E
GAMPAHA
KEGALLE
BADULLA
NUWARA ELIYA
BADULLA FOR SOLAR DEVELOPMENT
Latitude : 6°59'39.35"N
Longitude : 81°8'5.94"E
COLOMBO
MONERAGALA
RATNAPURA FOR SOLAR DEVELOPMENT
Latitude : 6°41'17.81"N
Longitude : 80°44'47.48"E
KALUTARA
HAMBANTOTA
GALLE
MATARA
SOLAR
Peaks
Roads
Railway
Streams
Cities
Lagoons
Forests
Tanks
Divsec
district
Boundary
OSM Standard
0 25 50 75 100 Km
1 : 1600000

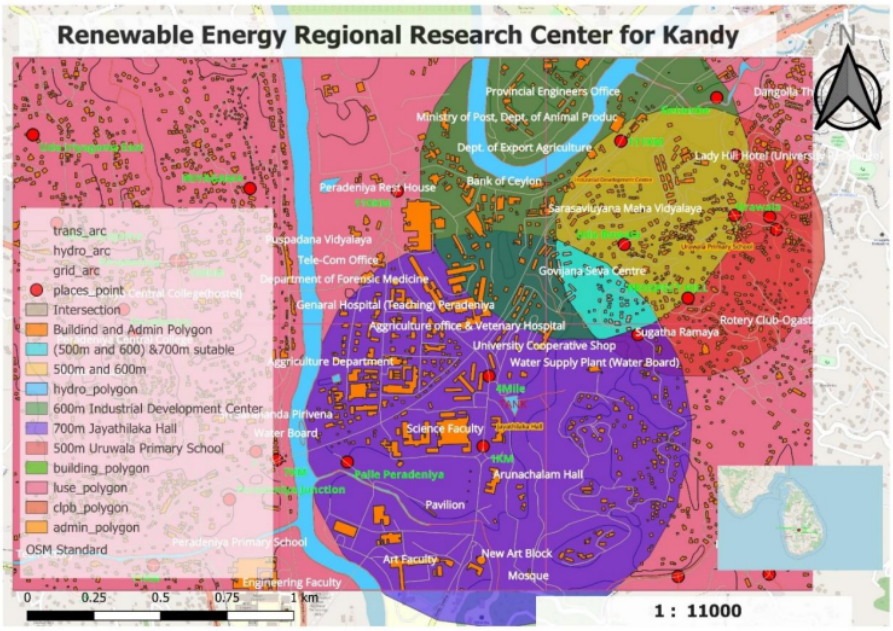

Potential Location For Renewable Energy Generation In Sri Lanka (Wind)
N
JAFFNA
IAFFNA FOR WIND DEVELOPMENT
Latitude :9°34'9.83"N
Longitude : 80°27'34.22"E
KILINOCHCHI
KILINOCHCHI FOR WIND DEVELOPMENT
Latitude :9°26'8.96"N
Longitude : 80°18'27.76"E
MANNAR FOR WIND DEVELOPMENT
Latitude : 9° 6'25.53"N
Longitude : 80° 6'32.79"E
MULLAITIVU
MANNAR FOR WIND DEVELOPMENT
Latitude : 9° 1'8.47"N
Longitude : 79°49'52.26"E
MANNAR
VAVUNIYA
TRINCOMALEE
ANURADHAPURA FOR WIND DEVELOPMENT
Latitude :8°26'1.59"N
Longitude : 80°22'39.87"E
ANURADHAPURA
PUTTALAM FOR WIND DEVELOPMENT
Latitude :8°16'6.63"N
Longitude : 79°49'24.44"E
ANURADHAPURA FOR WIND DEVELOPMENT
Latitude :8°35'42.66"N
Longitude : 80°42'1.58"E
PUTTALAM
POLONNARUWA
BATTICALOA
KURUNEGALA
MATALE
MATALE FOR WIND DEVELOPMENT
Latitude : 7°24'45.93"N
Longitude : 80°39'37.15"E
KANDY
AMPARA
GAMPAHA
KEGALLE
BADULLA
NUWARA ELIYA
COLOMBO
RATNAPURA FOR WIND DEVELOPMENT
Latitude :6°44'26.40"N
Longitude : 80°47'39.63"E
MONERAGALA
KALUTARA
RATNAPURA
HAMBANTOTA
HAMBANTOTA FOR WIND DEVELOPMENT
Latitude : 6°15'3.90"N
Longitude : 81°27'20.07"E
GALLE
MATARA
Wind
Peaks
Roads
Railway
Streams
Cities
Lagoons
Forests
Tanks
Divsec
district
Boundary
OSM Standard
0 25 50 75 100 Km
1 : 1600000

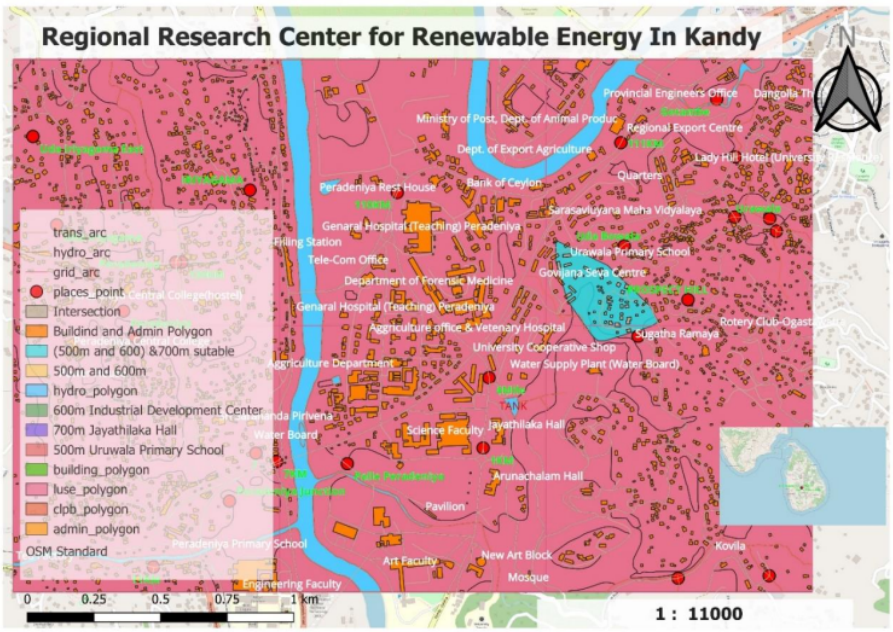

Potential Location For Renewable Energy Generation In Sri Lanka (Biomass)
N
JAFFNA
KILINOCHCHI
MULLAITIVU
MANNAR
VAVUNIYA
TRINCOMALEE
ANURADHAPURA
POLONNARUWA FOR BIOMASS DEVELOPMENT
Latitude : 7°59'38.60"N
Longitude : 81°16'28.06"E
PUTTALAM
POLONNARUWA
BATTICALOA
KURUNEGALA
MATALE
BATTICALOA FOR BIOMASS DEVELOPMENT
Latitude : 7°28'50.26"N
Longitude : 81°28'5.03"E
KANDY
AMPARA
BADULLA FOR BIOMASS DEVELOPMENT
Latitude : 7°15'17.65"N
Longitude : 81°12'49.24"E
GAMPAHA
KEGALLE
NUWARAELIYA
BADULLA
COLOMBO
MONERAGALA FOR BIOMASS DEVELOPMENT
Latitude : 6°44'44.49"N
Longitude : 81°25'7.81"E
KALUTARA
RATNAPURA
HAMBANTOTA FOR BIOMASS DEVELOPMENT
Latitude : 6°24'11.07"N
Longitude : 81°3'24.64"E
HAMBANTOTA
GALLE
MATARA
Biomass
Peaks
Roads
Railway
Streams
Cities
Lagoons
Forests
Tanks
Divsec
district
Boundary
OSM Standard
0 25 50 75 100 Km
1 : 1600000

Chapter 8

Task H

Described in this chapter, a map has been created to locate suitable land for the new development of a regional research center on renewable energy in Kandy. The given shape file has been used to create this map. Also, 3 feasible areas are used to create this map and these areas are 500 meters from Uruwala Primary School, 600 meters from Industrial Development, and 700 meters from Jayathilaka Hall respectively.





Renewable Energy Regional Research Center for Kandy	
Total number of buildings situated within the suitability area at present.	55
Total land area occupied by the buildings within the suitability area.	73421 m^2
Total suitable land area	7928 m^2

As shown in the picture above, three locations were used to design the intersection, Uruwala Primary School, Industrial Development Center and Jayathilake Hall. The red circle on the map is 500 meters from Uruwala Primary School, the green circle is 600 meters from Industrial Development Center and the blue circle is 700 meters from Jayathilaka Hall. Thus the part shown in sky blue is identified as the suitable part to create the "Regional Research Center for Renewable Energy". Agricultural Service Center is located around this selected area. To the right of this selected section is Sugatharamaya. The block chosen to create the Regional Research Center for Renewable Energy spans 55 buildings. Also, the total area occupied by buildings in the appropriate area is 73421 square meters. The total suitable area is 7928 square meters.

Ultimately, the creation of the Regional Research Center for Renewable Energy represents a deliberate move to support regional innovation, education and sustainable development. The research center has the potential to become a major hub for

renewable energy research, leveraging the advantages of the selected site and addressing potential issues, significantly aiding efforts to transform the island's energy sector and further its sustainability goals.

Conclusion

To sum up, to address urgent power-generating concerns and fulfil rising energy demands, the Ministry of Power and Renewable Energy has launched a comprehensive research initiative. Enhancing energy efficiency in building cooling systems has been a major area of attention. This is important since these systems play a significant role in the use of electricity in the residential and commercial sectors.

The project has adopted a diverse strategy and is using technologies including R, R-studio, QGIS, and PostgreSQL. Building cooling and structural characteristics may be correlated, according to a preliminary examination of the "energy_efficiency_data.csv" dataset and its supporting data dictionary. These realizations are essential for later stages, especially for creating accurate statistical models that capture the complex interactions between cooling systems and associated structural elements.

Using QGIS and open-layer plugins, the team has further gone into geospatial analysis to provide an improved informative map. This map shows potential areas for solar power plant development while considering relevant aspects such as existing buildings, roads, and vegetation. This project offers useful insights into how solar energy might be used to alleviate Sri Lanka's energy sector's difficulties.

An important project in and of itself has been the creation of the PostgreSQL geographic database "SLPetrolium-2023". Important data on the district level consumption of petrol and diesel is included in this database. The spread of petroleum product use may be clearly shown using thematic maps created from this source. Additionally, by identifying prospective locations for renewable energy generation, the initiative has matched its objectives with the vision of the Sri Lanka Sustainable Energy Authority.

In conclusion, the Ministry's integrated strategy for addressing energy concerns combines data-driven research, cutting-edge technology, and a keen understanding of local subtleties. Significant contributions to Sri Lanka's sustainable energy future are anticipated, along with initiatives for effective power generation, decreased consumption, and increased dependence on renewable energy sources.

Reference

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