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INTRODUCTION

Today's world has become a world of development with electricity. It is a fact that everyone knows that there is no existence in a world without electricity. Electricity consumption is gradually increasing with the increase in population size. However, during power generation, grants are created under two methods. The two types are mentioned as renewable and non-renewable. However, due to the depletion of non-renewable energy, people are turning to renewable energy.

Efforts are also made to save the existing power along with turning to other energy sources. There, in questions ‘A’ and ‘B’ of the assignment provided to analyze the factors needed to reduce the electricity used for cooling the buildings. Based on the data file provided there, the factors that are required to maintain the cooling of a building will be analyzed. Based on these factors, it will be possible to reduce the cooling of the building by using AC machines or electric fans.

The development of renewable energy in Sri Lanka will be discussed in the rest of the issues. Regarding the 'C' problem, a map classified into districts according to the amount of land suitable for the development of Sulan electricity will be created. Also, by problem 'D', a map is created based on total capacity, total estimated energy and total area based on the electricity produced by the existing solar power plants. Also, digitization of the area provided in problem 'E' is done. Forests, trees, roads etc. are marked on the map.

The fuel station in Sri Lanka is discussed in problem 'f'. Namely, the expansion of the fuel stations in the districts as well as the information about the diesel and petrol in relation to the respective districts will be mapped here. Also, in the 'G' problem, there is a map showing suitable locations for creating wind energy, solar energy, etc. in Sri Lanka. Also, in the 'H' problem mentioned as the last problem, finding suitable land for the new development of a regional research center for renewable energy in Kandy and searching for information about that area is done in that problem. At the end of this pamphlet, you will be able to get an understanding of the renewable energy products and their suitable areas, as well as the things that should be done for cooling during the construction of a building.

QUESTION A

The Ministry of Power and Renewable Energy is conducting various research studies related to the electricity generation required in the country using local as well as global data. Residential and commercial refrigeration can be identified as a major source of electricity consumption. Therefore, to reduce the consumption of electricity, attention is focused on the construction of buildings so as to keep the cooling of the buildings. A dataset named "*energy_efficiency_data.csv*" is provided and its data dictionary captures potential relationships between building cooling and associated building structural factors related to building shapes.

Relative_(	Surface_A	Wall_Area	Roof_Area	Overall_H	Orientatic	Glazing_A	Glazing_A	Heating_L	Cooling_Load
0.98	514.5	294	110.25	7	2	0	0	15.55	21.33
0.98	514.5	294	110.25	7	3	0	0	15.55	21.33
0.98	514.5	294	110.25	7	4	0	0	15.55	21.33
0.98	514.5	294	110.25	7	5	0	0	15.55	21.33
0.9	563.5	318.5	122.5	7	2	0	0	20.84	28.28
0.9	563.5	318.5	122.5	7	3	0	0	21.46	25.38
0.9	563.5	318.5	122.5	7	4	0	0	20.71	25.16
0.9	563.5	318.5	122.5	7	5	0	0	19.68	29.6
0.86	588	294	147	7	2	0	0	19.5	27.3
0.86	588	294	147	7	3	0	0	19.95	21.97
0.86	588	294	147	7	4	0	0	19.34	23.49
0.86	588	294	147	7	5	0	0	18.31	27.87
0.82	612.5	318.5	147	7	2	0	0	17.05	23.77
0.82	612.5	318.5	147	7	3	0	0	17.41	21.46
0.82	612.5	318.5	147	7	4	0	0	16.95	21.16
0.82	612.5	318.5	147	7	5	0	0	15.98	24.93
0.79	637	343	147	7	2	0	0	28.52	37.73
0.79	637	343	147	7	3	0	0	29.9	31.27
0.79	637	343	147	7	4	0	0	29.63	30.93
0.79	637	343	147	7	5	0	0	28.75	39.44
0.76	661.5	416.5	122.5	7	2	0	0	24.77	29.79
0.76	661.5	416.5	122.5	7	3	0	0	23.93	29.68
0.76	661.5	416.5	122.5	7	4	0	0	24.77	29.79
0.76	661.5	416.5	122.5	7	5	0	0	23.93	29.4
0.74	686	245	220.5	3.5	2	0	0	6.07	10.9
0.74	686	245	220.5	3.5	3	0	0	6.05	11.19
0.74	686	245	220.5	3.5	4	0	0	6.01	10.94
0.74	686	245	220.5	3.5	5	0	0	6.04	11.17
0.71	710.5	269.5	220.5	3.5	2	0	0	6.37	11.27
0.71	710.5	269.5	220.5	3.5	3	0	0	6.4	11.72
0.71	710.5	269.5	220.5	3.5	4	0	0	6.37	11.29
0.71	710.5	269.5	220.5	3.5	5	0	0	6.4	11.67
0.69	735	294	220.5	3.5	2	0	0	6.85	11.74
0.69	735	294	220.5	3.5	3	0	0	6.79	12.05
0.69	735	294	220.5	3.5	4	0	0	6.77	11.73
0.69	735	294	220.5	3.5	5	0	0	6.81	11.93
0.66	759.5	318.5	220.5	3.5	2	0	0	7.18	12.4

Below are screenshots of a dataset and its data dictionary.

The Data Dictionary of Energy Efficiency Data Set (extracted from a USA Case Study)

Index	Variable	Description
1	Relative_Compactness	Relative compactness. This is the measure compactness of the closure or building
2	Surface_Area	Surface Area of the building. This is measured in square feet.
3	Wall_Area	Area of the building covered by with of the wall. This is measured in *square feet*.
4	Roof_Area	Area covered under roofs. This is measured in *square feet*.
5	Overall_Height	Overall Height of the building. This is measured in *feet*.
6	Orientation	Orientation of the building based on direction such as North Facing, South Facing etc.
7	Glazing_Area	Total Area of the wall which is glass. This is measured in *square feet*.
8	Glazing_Area_Distribution	How Glazing Area distributed within the whole building.
9	Heating_Load	How much heating load is required to heat the building. This is measured in *BTU(British Thermal Units)*.
10	Cooling_Load	How much load is required to cool the building. This is measured in *BTU(British Thermal Units)*.
		1 BTU = 0.00029307107 kW (Kilo Watts).

Analyzing the energy_efficiency_data.csv data file

1.1.1. Import the data set.

First the data file is uploaded to R-Studio. The data file is first cleaned for data analysis. There the null values in the data file are removed. As mentioned here, it consists of 768 rows and 10 columns. Then the display of the data file is clearly shown by the following screenshot.

```
#import the dataset
unclean_data <- read.csv("energy_efficiency_data.csv")

#data preprocessing
energy_data <- na.omit(unclean_data)

#data row count
nrow(energy_data)

#data column count
ncol(energy_data)

print(head_energy)
```

```
>
> print(head_energy)
  Relative_Compactness Surface_Area Wall_Area Roof_Area Overall_Height
1                 0.98        514.5     294.0    110.25              7
2                 0.98        514.5     294.0    110.25              7
3                 0.98        514.5     294.0    110.25              7
4                 0.98        514.5     294.0    110.25              7
5                 0.90        563.5     318.5    122.50              7
6                 0.90        563.5     318.5    122.50              7
  Orientation Glazing_Area Glazing_Area_Distribution Heating_Load Cooling_Load
1           2            0                         0        15.55        21.33
2           3            0                         0        15.55        21.33
3           4            0                         0        15.55        21.33
4           5            0                         0        15.55        21.33
5           2            0                         0        20.84        28.28
6           3            0                         0        21.46        25.38
>
```

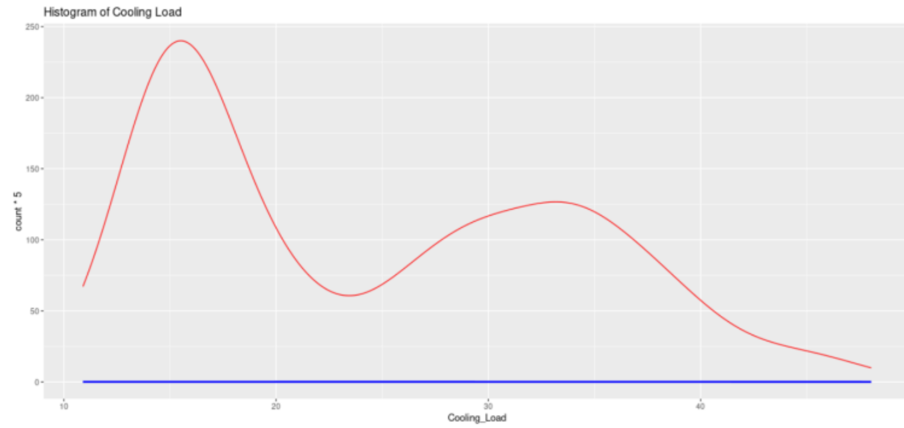
1.1.2. Search Categorical and Continuous values.

Categorical values and continuous separation are important in data theft analysis. The reserved data is categorized below.

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

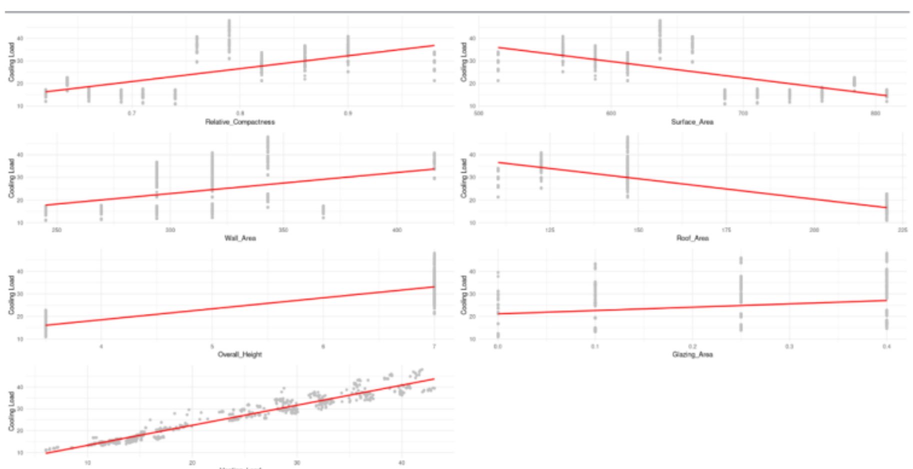
1.1.3. Cooling Load data distribution

Bell curves related to the 'Coolant Load' column can be seen in the screenshot below. where the distribution of the data file is shown with respect to that column and the standard deviation of the data file is used to construct it. The distribution of this data file consists of two peaks and is called a multivariate distribution. The analysis is performed assuming that this data file is bell curved.



1.1.4. Scatter plot

A scatter plot is used as a data visualization used in statistics and data analysis to show the relationship of variables. However, categorical data is not used here, and continuous data is used. The data taken from the war file contains 'Orientation' and 'Glazing Area Distribution' as categorical data, so it is not used to create a scatter plot. Below is the scatter plot created for continuous data.



This scatter plot is used to study the correlations between Cooling_Load and other variables. In this regard, a good relationship between the Heating Load and the Cooling_Load can be seen from the scatter plot collections. But it is not seen that there is a good relationship with other factors. However, here the correlation matrix and summary are used to get accurate information about the correlation data.

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

Above is the model designed to examine the relationship between Cooling_Load and other variables. However, based on this model, the analysis of the relationship between Cooling_Load and each of the variables is given below.

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

The summary of the linear regression model is used to get a clear description of the graphs displayed by the scatter plot. Based on the scatter plot drawn above, it was assumed that there is a relationship between Cooling_Load and Heating Load. Also, the assumption was confirmed by this. However, according to the data obtained here, it can be seen that there is a relationship between Cooling_Load and Glazing_Area, Overall_Height, Relative_Compactness. According to the information obtained here, it is clearly seen by the p-value that there is a very good relationship between Cooling_Load and Heating Load.

1.1.5. Finding relationships

1.1.5.1. Cooling_Load and Heating_Load Relationship

Alternative Hypothesis	There is a significant relationship with the cooling load and the heating load of the building
Null Hypothesis	There is no significant relationship with the cooling load and the heating load of the building

```
        Pearson's product-moment correlation

data:  energy_data$Cooling_Load and energy_data$Heating_Load
t = 123.67, df = 766, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.9722375 0.9790180
sample estimates:
      cor
0.9758618
```

Considering Cooling_Load and Heating_Load, p-value = 2.2e-16 is obtained, and the value is less than 0.05, so it seems that there is a very good relationship. Therefore, null hypothesis is removed here and seems to be very well related.

1.1.5.2. Cooling_Load and Glazing_Area Relationship

Alternative Hypothesis	There is a significant relationship with the cooling load and the Glazing_Area of the building
Null Hypothesis	There is no significant relationship with the cooling load and the Glazing_Area of the building

```
        Pearson's product-moment correlation

data:  energy_data$Cooling_Load and energy_data$Glazing_Area
t = 5.8708, df = 766, p-value = 6.457e-09
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.1387982 0.2742237
sample estimates:
     cor
0.207505
```

Regarding Cooling_Load and Glazing Area, p-value = 6.457e-09 and the value is less than 0.05, so it seems that there is a good relationship between Cooling_Load and

Glazing Area. Therefore, the null hypothesis is rejected, and the Alternative Hypothesis is confirmed to be correct.

1.1.5.3. Cooling_Load and Overall_Height Relationship

Alternative Hypothesis	There is a significant relationship with the cooling load and the Overall_Height of the building
Null Hypothesis	There is no significant relationship with the cooling load and the Overall_Height of the building

```
        Pearson's product-moment correlation

data:  energy_data$Cooling_Load and energy_data$Overall_Height
t = 55.777, df = 766, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.8808626 0.9089291
sample estimates:
      cor 
0.8957852
```

Considering Cooling_Load and Overall_Height, p-value = 2.2e-16 and the value is less than 0.05, so it seems that there is a good relationship between Cooling_Load and Overall_Height. Therefore, the null hypothesis is rejected, and the Alternative Hypothesis is confirmed to be correct.

1.1.5.4. Cooling_Load and Relative_Compactness Relationship

Alternative Hypothesis	There is a significant relationship with the cooling load and the Relative_Compactness of the building
Null Hypothesis	There is no significant relationship with the cooling load and the Relative_Compactness of the building

```
        Pearson's product-moment correlation

data:  energy_data$Cooling_Load and energy_data$Relative_Compactness
t = 22.71, df = 766, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.5900749 0.6748011
sample estimates:
      cor 
0.6343391
```

Considering Cooling_Load and Relative_Compactness, p-value = 2.2e-16 and the value is less than 0.05, so it seems that there is a good relationship between Cooling_Load and Relative_Compactness. Therefore, the null hypothesis is rejected, and the Alternative Hypothesis is confirmed to be correct.

QUESTION B

Summary Of the lm () function

2.1. Cooling_Load and Heating_Load Relationship

```
> lm_model1 <- lm(energy_data$Cooling_Load ~ energy_data$Heating_Load,data = energy_data)
> print(lm_model1 )

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

Coefficients:
             (Intercept)  energy_data$Heating_Load
                  4.0636                    0.9201
```

$$Y\ energy\_data\$cooling\_Load = 4.0636 + 0.9201\ X\ energy\_data\$Heating\_Load$$

2.1.1. Summary Statistic for lm () Function

```
Call:
lm(formula = Cooling_Load ~ Heating_Load, data = energy_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
```

Considering the relationship between Cooling_Load and Heating_Load, a very high correlation is obtained as obtained above. It seems that there is a good relationship by getting a very small value of 2.2e-16 as p-value. Also, there is a high correlation between Heating_Load and other factors.

2.2. Cooling_Load and Glazing_Area Relationship

```
> lm_model2 <- lm(energy_data$Cooling_Load ~ energy_data$Glazing_Area ,data = energy_data)
> print(lm_model2 )

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

Coefficients:
             (Intercept)  energy_data$Glazing_Area
                   21.11                     14.82
```

$$\boxed{Y\ energy\_data\$cooling\_Load = 21.11 + 14.82\ X\ energy\_data\$Glazing\_Area}$$

2.2.1. Summary Statistic for lm () Function

```
Call:
lm(formula = Cooling_Load ~ Glazing_Area, data = energy_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
```

Considering the relationship between Cooling_Load and Glazing_Area, a relationship can be seen as obtained above. There it seems that there is a relationship by getting a value of 6.457e-09 as p-value. According to the p-value here, it appears that there is a relationship.

2.3. Cooling_Load and Overall_Height Relationship

```
> lm_model3 <- lm(Cooling_Load ~ energy_data$Overall_Height  ,data = energy_data)
> print(lm_model3 )

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

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

$$Y\ energy\_data\$cooling\_Load = -0.9612 + 4.866X\ energy\_data\$Overall\_Hight$$

2.3.1. Summary Statistic for lm () Function

```
Call:
lm(formula = Cooling_Load ~ Overall_Height, data = energy_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
```

Considering the relationship between Cooling_Load and Overall_Height, a relationship can be seen as obtained above. There it seems that there is a relationship by getting a value of 2.2e-16 as p-value. According to the p-value here, it appears that there is a relationship.

2.4. Cooling_Load and Relative_Compactness Relationship

```
> lm_model4 <- lm(Cooling_Load ~ energy_data$Relative_Compactness   ,data = energy_data)
> print(lm_model4 )

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

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

$$Yenergy\_data\$cooling\_Load = -19.01 + 57.05X\ energy\_data\$Relative\_Compactnes$$

2.4.1. Summary Statistic for lm () Function

```
Call:
lm(formula = Cooling_Load ~ Relative_Compactness, data = energy_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
```

Considering the relationship between Cooling_Load and Relative_Compactness, a relationship can be seen as obtained above. There it seems that there is a relationship by getting a value of 2.2e-16 as p-value. According to the p-value here, it appears that there is a relationship.

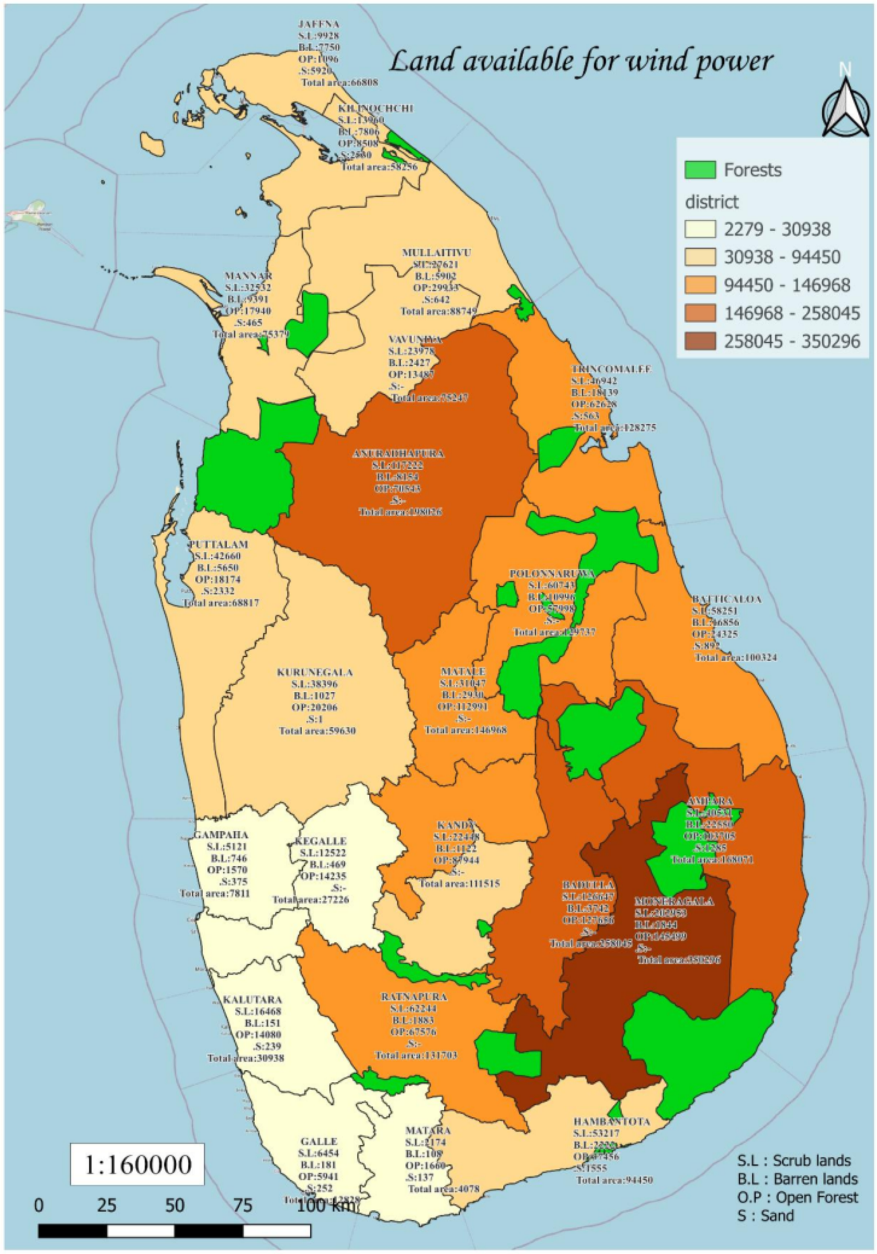
QUESTION C

In today's world, people are focusing on the development of regenerative energy. Wind energy can be seen as one sector there. In this work, we are currently looking for viable land for wind energy development in Sri Lanka. Thus, the amount of viable land is calculated according to the district and displayed in a map of Sri Lanka.

To accomplish this task, the data set "***SLWindPowerLand_21_23.csv***" was created containing all the information in Table 7.1 of the "Renewable Energy Development Plan 2021-2026" report published by the Sri Lanka Sunitya Energy Authority. A screenshot of the created file is shown below.

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

Below is a map of Sri Lanka with areas suitable for wind power development on the map using the "SLWindPowerLand_21_23.csv" dataset.



Land available for wind power
N
Forests
district
2279 - 30938
30938 - 94450
94450 - 146968
146968 - 258045
258045 - 350296
1:160000
0 25 50 75 100 km
S.L : Scrub lands
B.L : Barren lands
O.P : Open Forest
S : Sand

Above is a map that visualizes information about potential land, separated by districts in Sri Lanka using the "**SLWindPowerLand_21_23.csv**" data set noted above. In this map they are displayed in 5 colors according to the values of hectares of viable land (ha) when showing them as districts. The kangas used there, and the corresponding colors are given below. Also, the existing forest areas are shown in green color on the map.

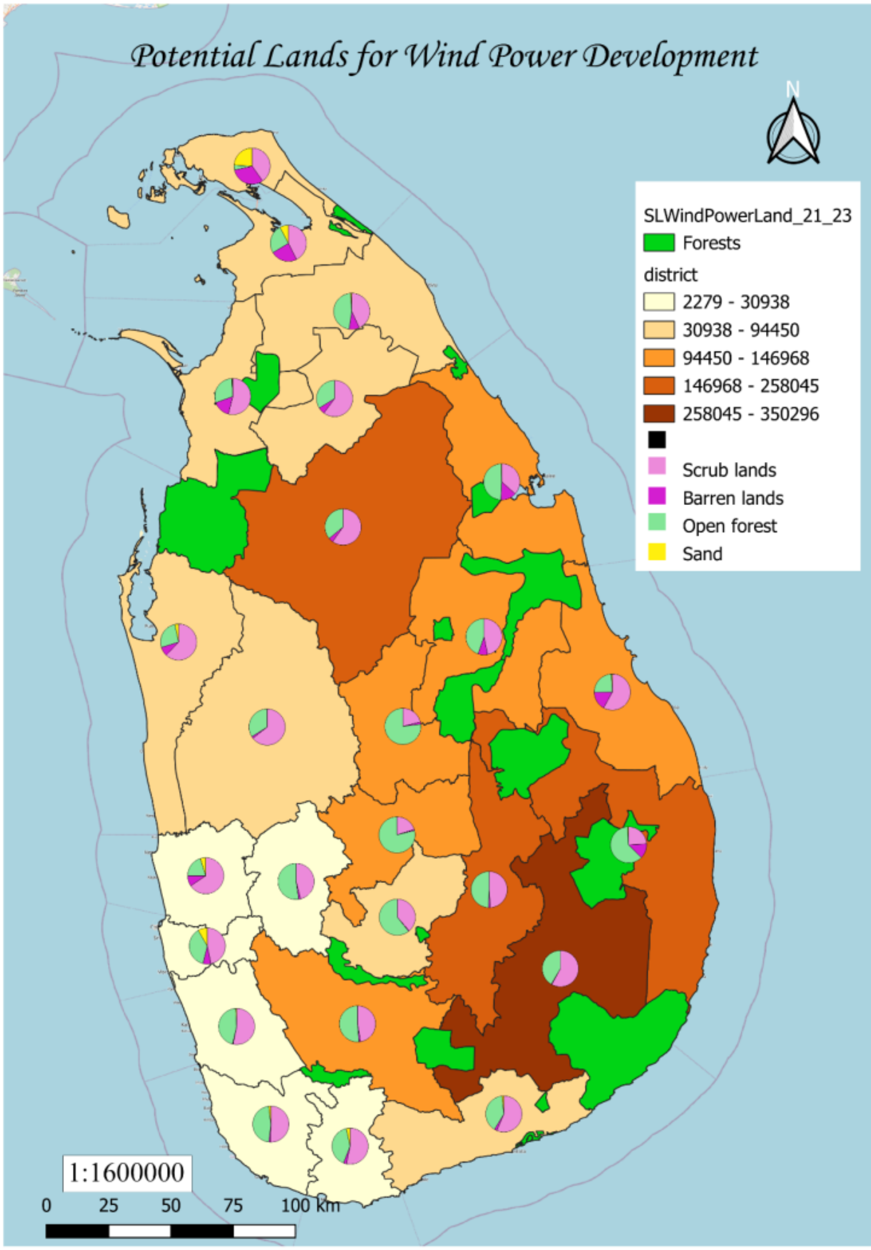
Symbol	Values	Legend
✓	2279.00 - 30938.00	2279 - 30938
✓	30938.00 - 94450.00	30938 - 94450
✓	94450.00 - 146968.00	94450 - 146968
✓	146968.00 - 258045.00	146968 - 258045
✓	258045.00 - 350296.00	258045 - 350296

According to the map created here, the dark color (brown) is the district that contains a large amount of viable land for solar energy production. It can also be seen that the amount of viable land available in those districts also decreases depending on the size of the selection. The least i.e., white indicates the district with the least viable land for wind power generation in Sri Lanka.

As I have shown the map, a lot of viable land for wind energy development in Sri Lanka has been included in Monaragala district. This area is mentioned as 350296 hectares. Also, Badulla, Anuradhapura, and Ampara districts can be seen as districts with viable land. According to the map, less viable land can be seen in the districts oriented towards the South-East and West directions. Among them, the two least viable lands in Colombo district were taken. The amount is stated as 2279 hectares. Also, Kegalle, Galle, Gampaha and Matara can be taken as other districts with minimum land. Some of the mentioned areas and the amount of land in those areas are given below.

District	Total
MONERAGALA	350296
BADULLA	258045
ANURADHAPURA	198026
AMPARA	168071
MATALE	146968
//	
HAMBANTOTA	94450
MULLAITIVU	88749
NUWARA ELIYA	86944
MANNAR	75379
VAVUNIYA	75247
//	
KEGALLE	27226
GALLE	12828
GAMPAHA	7811
MATARA	4078
COLOMBO	2279

In order to obtain the amount of land mentioned above, it is important to find out which type of land is suitable for this in those districts. For this, using "**SLWindPowerLand_21_23.csv**", the pie chart was used to determine what type of area conditions the Sri Lanka map is district wise. Here, the amount of scrub land, barren land, open forest, and sand in the district will be displayed.



Potential Lands for Wind Power Development
N
SLWindPowerLand_21_23
Forests
district
2279 - 30938
30938 - 94450
94450 - 146968
146968 - 258045
258045 - 350296
Scrub lands
Barren lands
Open forest
Sand
1:1600000
0 25 50 75 100 km

By including the pie charts in the table, the map has been given a good bar. We know that most of the viable land can be seen in Monaragala district. According to the pie chart contained in the above map, about 60% percentage of scrubland (2002953ha) of viable land for producing solar energy can be seen in Monaragala district. Also, in delineating the value of wasteland and open space, two amounts of 1844ha and 145499ha can be taken.

Also, the two districts of Anuradhapura and Badulla, which seem to have the highest amount of viable land, are occupied by a large amount of barren land. Also, open forests in these areas have been identified as viable land. As for the districts with the highest viable land, all five appear to be areas of scrubland and open forest. The decrease in population in these areas can also be seen as another reason for its desirability. Due to the excessive noise generated by these wind power plants; the vicinity of these power plants is unsuitable for human habitation.

In focusing on the northern province, in addition to the districts with more viable land in that province, garden/gardens, rarely used cultivated land, grass land, palm tree land, coconut land will be considered. Here, attention has been focused on these sectors in Jaffna, Kilinochchi, Mannarama, Mullaitivu and Vavuniya districts. Pie charts display that information in detail.

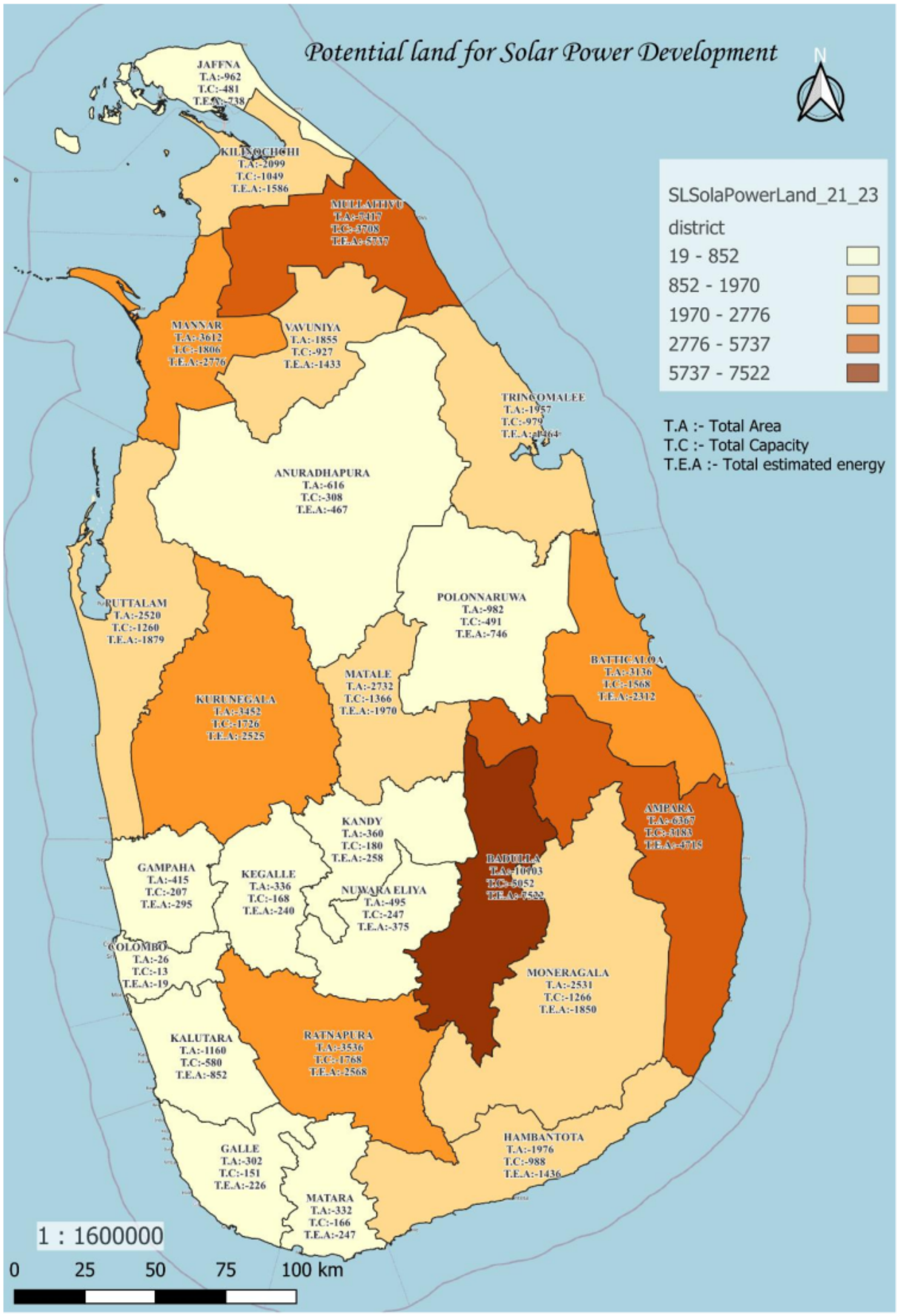
However, according to the map, when attention is directed to the districts that have the least viable amount of land, it appears that these districts are the districts with the highest population. That was also the reason for the minimum amount of land available for Colombo district. Also, the influence of wind may have affected those areas. However, the districts of Gampaha, Colombo and Kalutara are small, which may lead to the ownership of a minimum amount of land.

QUESTION D

Below is a data file created according to the tables regarding the potential land for solar energy development mentioned in the Renewable Energy Development Plan 2021-2026 report published by the Sri Lanka Solar Energy Authority.

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

A data file named "SLSolaPowerLand_21_23.csv" was created by creating the data in Table 7.4. Here the district name, total area (hectares), total capacity (MW) and total estimated energy (GWh) are shown in a Sri Lankan district map. A map created using the information in the above data file is shown.



Looking at the above map, the 25 focus districts are classified according to the total estimated energy that can be produced by solar energy. There, according to the estimated value, they have been divided into 5 sections and displayed in the respective districts on the map. That is, the estimated value is divided into sections such as 19-852,852-1970 etc. However, special colors have been given to the map for those sections. The values of the colors and sections thus used are given below.

Symbol	Values	Legend
✓	19.00 - 852.00	19 - 852
✓	852.00 - 1970.00	852 - 1970
✓	1970.00 - 2776.00	1970 - 2776
✓	2776.00 - 5737.00	2776 - 5737
✓	5737.00 - 7522.00	5737 - 7522

As shown in this map, the districts with the highest total estimated energy content are shown in dark brown. That is, according to the data in the data file in Badulla district, it is noted that the highest total estimated energy is in Badulla district. Here, the total area in Badulla district is 10103ha and the total capacity of that area is 5052MW and according to the data, the total estimated energy is 7522GWh.

After Badulla district, the highest total estimated energy is in Mullaitivu and Ampara districts. However, Badulla district has relatively less suitable area in these two districts (7417ha, 6367ha). The total estimated strength of those two districts is slightly lower than that of Badulla district. However, when taken next, the total estimated energy of the districts of Mannar, Ratnapura, Kurunegala and Batticaloa shows a decrease.

However, when studying the map, the two districts of Anuradhapura and Polonnaruwa are popular among the people as the districts where the sun shines continuously. However, these two districts have the lowest total estimated energy in the map. For this, the suitable areas may have decreased due to the flooding (Drainage of Tanks) of the network during the seasons. However, the highest total estimated energy is contained in Ratnapura district where the work horizon is least for those are Among the districts with the least total estimated energy, Colombo district stands out as the best. 19 GWh of energy will be created in this district and this will be the least production in Sri Lanka. The production of 13 MW has been a reason. Among the districts that do not produce >100MW, all the districts at the bottom of the data file, such as Ratnapura, Polonnaruwa, Anuradhapura, Nuwara Eliya, etc., are included, and since Ratnapura district has 1196MW between 20MW<x<100MW, the total estimated energy of Ratnapura district is high.as.

Here, all the districts displayed in white contain the minimum total estimated strength. However, this same data file arranged in descending order is shown below.

1	District	Total Area	Total Capacity	10MW<x<25MW	25MW<x<100MW	>100MW	Total estimated energy
2	BADULLA	10103	5052	831	2288	1933	7522
3	MULLAITIVU	7417	3708	719	1944	1046	5737
4	AMPARA	6367	3183	536	835	1812	4715
5	MANNAR	3612	1806	394	586	826	2776
6	RATNAPURA	3536	1768	572	1196	-	2568
7	KURUNEGALA	3452	1726	476	826	424	2525
8	BATTICALOA	3136	1568	275	986	307	2312
9	MATALE	2732	1366	206	438	722	1970
10	PUTTALAM	2520	1260	274	653	333	1879
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15	VAVUNIYA	1855	927	252	470	205	1433
16	KALUTARA	1160	580	121	176	283	852
17	POLONNARUWA	982	491	124	367	-	746
18	JAFFNA	962	481	39	144	297	738
19	ANURADHAPURA	616	308	35	273	-	467
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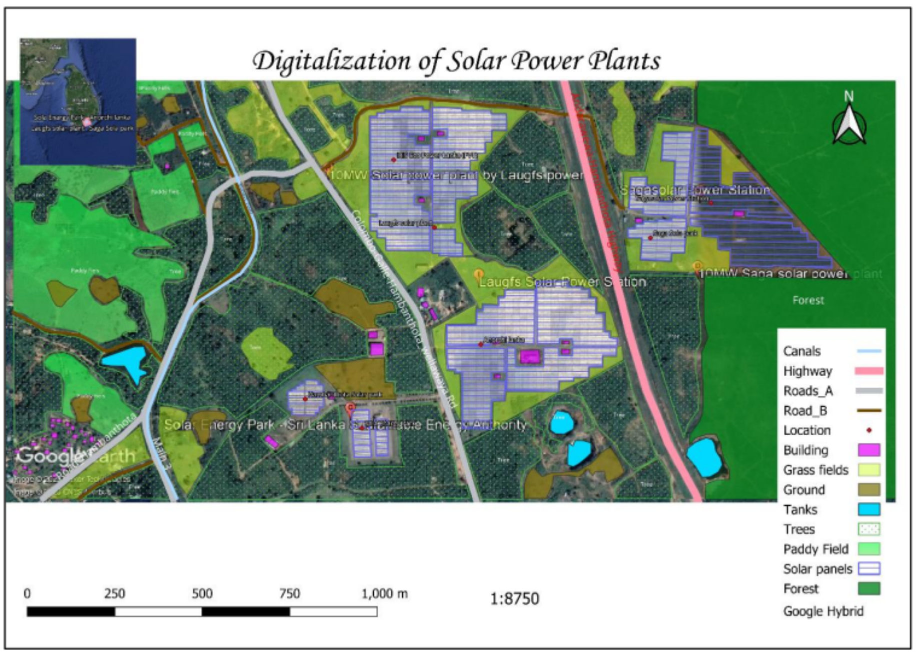
21	GAMPAHA	415	207	117	90	-	295
22	KANDY	360	180	74	106	-	258
23	MATARA	332	166	29	137	-	247
24	KEGALLE	336	168	128	40	-	240
25	GALLE	302	151	35	116	-	226
26	COLOMBO	26	13	13	-	-	19

QUESTION E

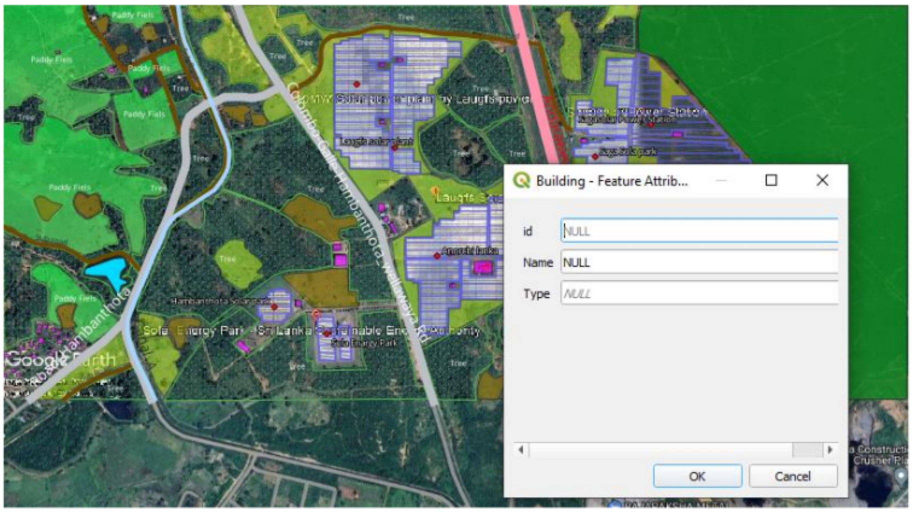
Today's world is focusing on renewable energy. The reason for that is the decrease in non-renewable energy sources like crude oil. However, even though the world pays attention to nuclear power, that energy is not suitable for small countries like Sri Lanka. Lack of sufficient space to build power plants seems to be a big reason. However, for the countries of Sri Lanka, among the renewable energies, Suraya power generation is the most appropriate.

There are several reasons why solar power is suitable for Sri Lanka. Here it can be seen that the sunlight that falls continuously throughout the year is a major factor. Also, a solar power plant in the Hambantota-Wellawaya area can be seen in the digitized area map below. Looking at the map, this solar power plant is located in a sparsely populated area, and as we all know, areas like Hambantota are areas where the sun shines most of the year. Here, according to the map, it seems that this area has been created with consideration for the ease of transportation and the area belonging to the forest.



Sri Lanka is known as a country that relies on hydropower for its electricity generation. During droughts, the process of hydropower generation stops. But during periods of drought, power cuts occur in the country. However, solar energy can be used as an alternative energy source. Then, in those times, the problems that may arise due to the creation of solar power plants in the areas filled with vacant land like the areas mentioned on the map will be minimized.

In relation to each part of the map mentioned above, id, Name and Type parts are included as follows.

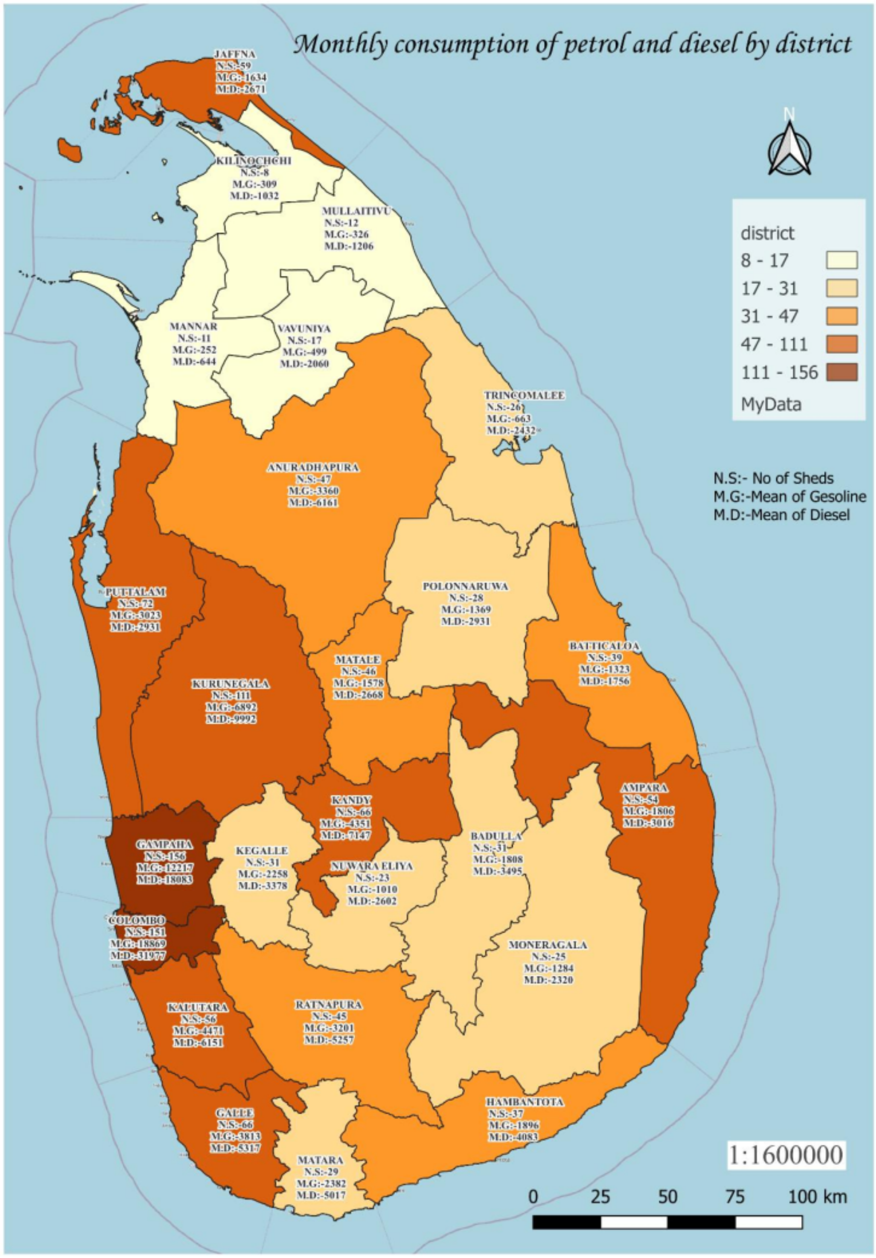


QUESTION F

In this work, using the data provided in the "SLPetrolium-2023" database, a thematic map classified according to the number of sheds according to the districts will be prepared. To complete this task, I used PostgreSQL to perform tasks in the "SLPetrolium-2023" database. To create this database, the Table: 5-03: Descriptive Statistics on Monthly Gasoline and Diesel Usage Separately, available in page no 33 of "Disaggregation of Petroleum Product Usage by End User Category" released by Sri Lanka Sustainable Energy Authority of the report") was created.

CSV format is required to perform this task first. After getting the content table of the report, "SLPetrolium-2023.csv" was created using the "District code" data table with the assignment. Here DISTRICT, No_of_Sheds, Gasoline_SD, Gasoline_Mean, Diesel_SD, Diesel_Mean headers are included in the data file. Below is a screenshot of it.

	A	B	C	D	E	F
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	2931
21	ANURADHAPURA	47	183	3360	2199	6161
22	POLONNARUWA	28	404	1369	1260	2931



To understand all of the above, first we pay attention to the different colors for each district on the map. However, it is divided into districts based on the number of sheds located in that district.

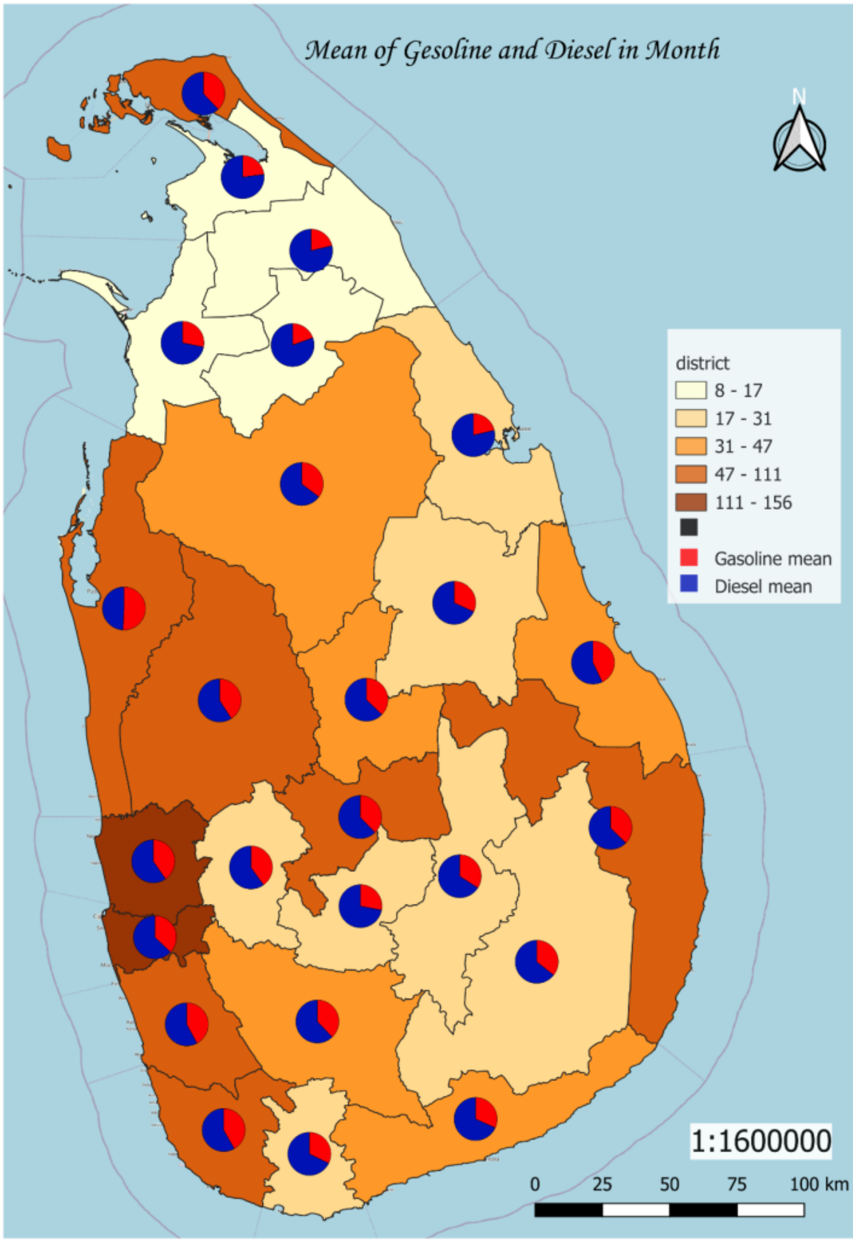
Symbol	Values	Legend
✓	8.000 - 17.000	8 - 17
✓	17.000 - 31.000	17 - 31
✓	31.000 - 47.000	31 - 47
✓	47.000 - 111.000	47 - 111
✓	111.000 - 156.000	111 - 156

Looking at this table, the districts are divided into 5 parts and mapped by sheds. Gampaha district has the highest number of sheds in one district at 156, but Colombo district has about 151 sheds, so that district also has the same color. However, attention can be drawn to a particular difference in the northern region of Sri Lanka. That is, the least number of sheds are located in Mullaitivu, Vavnia, Kilinochchi districts.

However, there is a difference in the Jaffna district because there are more sheds in the district compared to other districts in the Northern Plateau. There are 17 and 12 sheds in districts like Vavnia and Mullaitivu, but there are 59 sheds in Jaffna. The fact that Jaffna was the capital of the Northern Province was one of the reasons for this, while the population of the other regions was low.

However, an idea can be taken about the average usage of diesel and petrol according to each district using the map below. Similarly, in the district itself, the fuel consumption of diesel is comparable to that of petrol. This may be due to the fact that the equipment used in Sri Lanka's transport system and other sectors are powered by diesel.

Also, this map shows information about the use of diesel in official color and the use of petrol in red color. Here a specific chart is shown in Puttalam district. The graphs show that the consumption of diesel and petrol is relatively similar. But in all the other districts, the above-mentioned diesel will be used more and more.



Mean of Gesoline and Diesel in Month
N
district
8 - 17
17 - 31
31 - 47
47 - 111
111 - 156
Gasoline mean
Diesel mean
1:1600000
0
25
50
75
100 km

QUESTION G

In this task, suitable areas for renewable energy generation in the island are to be selected and mapped. However, in order to get the exact GPS locations of the areas identified by the Sri Lanka Solar Energy Authority, KML/KMZ files are created using Google Earth. Information such as latitude and longitude is then visualized on the location.

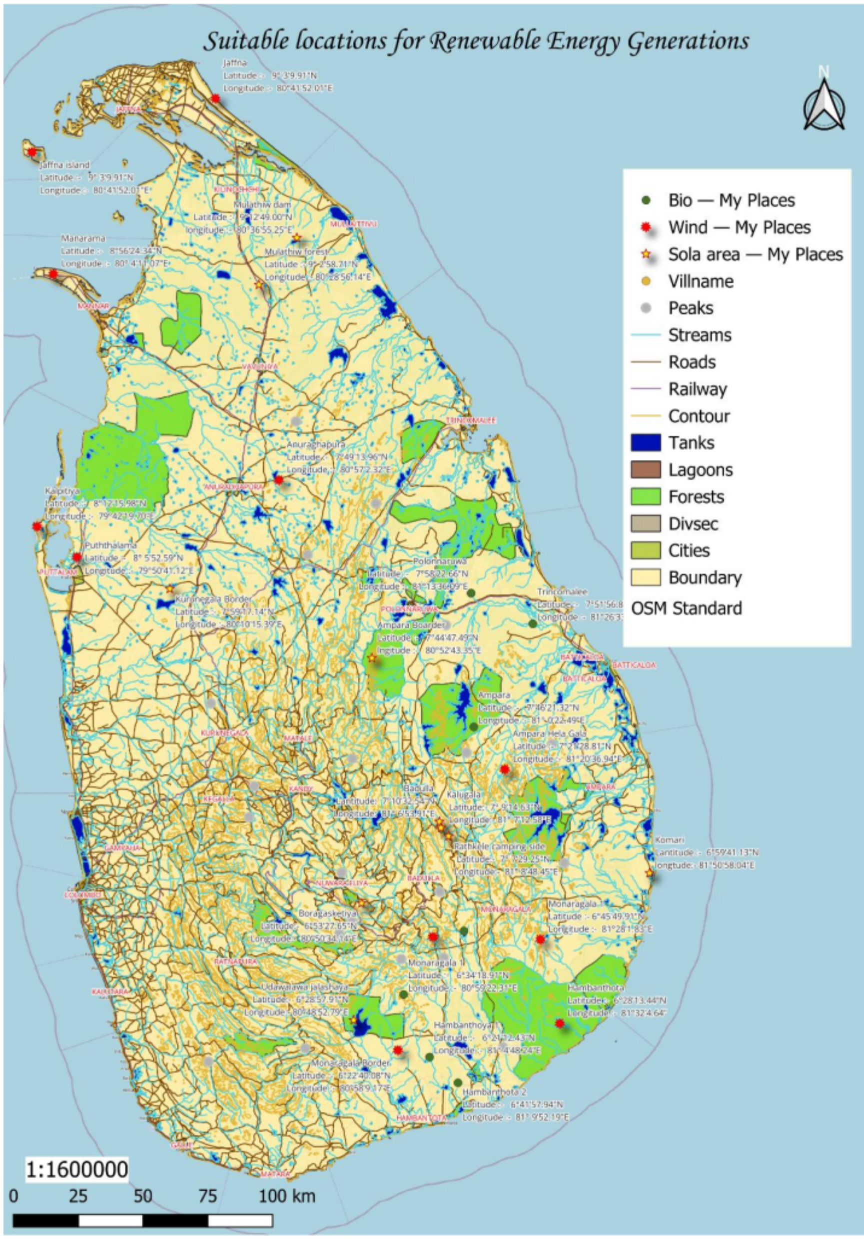
Among renewable energies, wind power, solar power and biomass were mapped here. In studying the above problem C, Monaragala district has been mentioned as the most suitable district for wind power. Therefore, suitable areas are marked in Monaragala district. Here, during the construction of wind power plants, due to their excessive noise, an area without human settlements was first selected. However, those places are marked to be forested areas in Monaragala district. No matter how the marking is done on the top of the mountains, the ease of transportation for maintenance work has also been emphasized.

Mountainous areas as well as coastal areas are the most suitable areas for wind power generation. Here there is a suitable record of the seashore listener in the areas of Puttalam, Hambantota, Jaffna. Also, the reservoir area has been mentioned as suitable areas for building power plants, where the area near Udawalawa reservoir is a suitable area for producing a power plant.

Badulla district has been mentioned as a district that has many suitable areas for creating solar power plants. Due to an area with mountains and valleys in the Badulla district, it is necessary to move to the top of the mountains to install these panels. The reason for this is because the light does not fall on properly on either sides of the mountain in the morning or in the evening. Hence, these are chosen to be installed in the pits at higher places.

Also, in the areas with reservoirs near the tanks, it is reserved for installation. However, several places along the canals have been mentioned as suitable places. Here in Mullaitivu, the areas where the sun shines for most of the year. It is possible to build solar power plants easily as there are few tall trees here. Because having tall trees to build in protected forests is expensive and causes environmental damage. Also, the areas with high population are not suitable because the space is minimal.

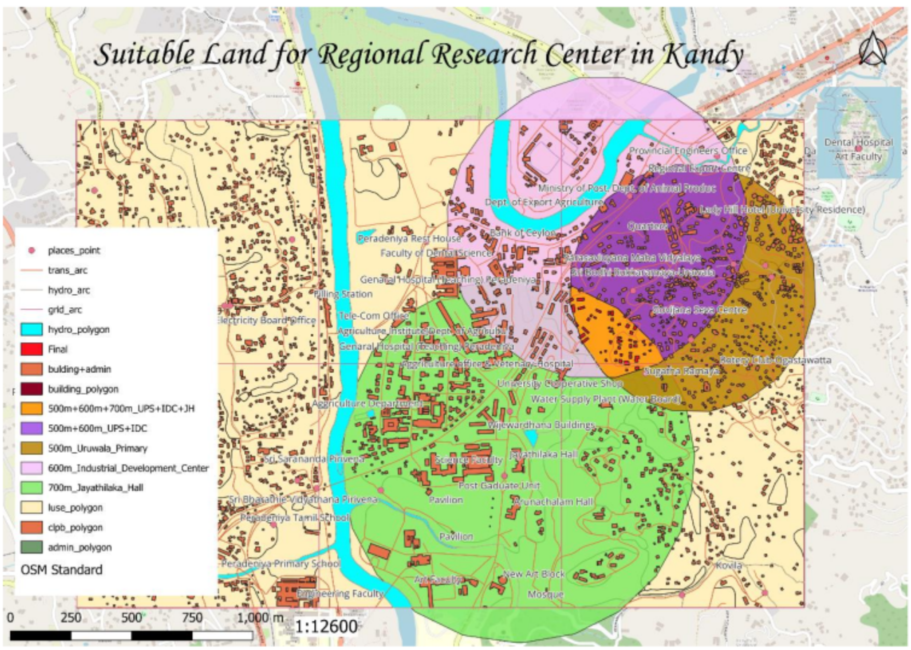
However, many areas in Monaragala district have been mentioned as suitable areas for creating biomass. In addition, there are suitable places for biomass production in Vavuniya District and Hambantota District. However, the suitable areas for renewable energy production in Sri Lanka are displayed separately in the map and thus a good overview can be obtained.

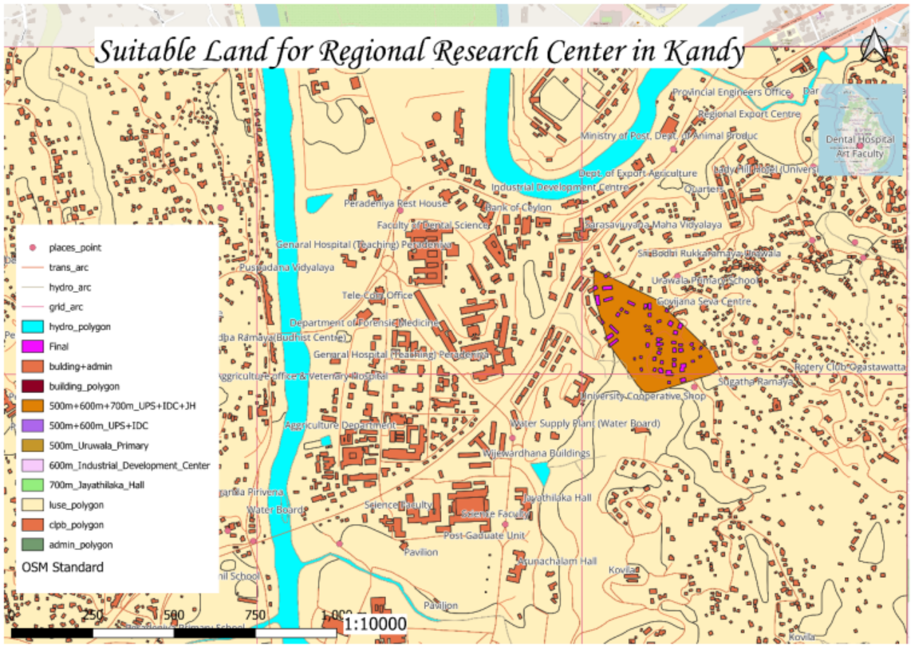

Suitable locations for Renewable Energy Generations
Bio — My Places
Wind — My Places
Sola area — My Places
Villname
Peaks
Streams
Roads
Railway
Contour
Tanks
Lagoons
Forests
Divsec
Cities
Boundary
OSM Standard
1:1600000
0
25
50
75
100 km

QUESTION H

In this work, a map has to be prepared to find a suitable land for the newly developed regional research center for renewable energy. However, there are several requirements to be met when searching for this land. There should be a 500m distance to Uruwala Primary School as a basic requirement. Also, it is unclear that 600m to the Industrial Development Center and 700m to the Jayathilaka Hall should be within a two-day walk.

While creating this map, the respective locations are buffered according to the required distances. There the respective place was taken as the center and the necessary distance was taken as the radius of the circle and the circles were created. Then the area common to all those areas was selected and reserved as the most suitable area for this purpose.





The map above shows the suitable land in orange color. However, considering this area, it is a piece of land with 55 buildings in this area. Here the buildings in the area are shown in purple.

Total number of buildings situated within the suitability area at present	55
Total land area occupied by the buildings within the suitability area.	73421m^2
Total suitable land area.	7928.76m^2

A regional research center for renewable energy consists of 55 buildings to find suitable land for new development. Also, the total area occupied by buildings in the suitability area is 73421m2 and the total suitable area is 7928.76m2. However, even within this suitable area, there may be areas unsuitable for building due to the presence of trees. It is also unsuitable for construction in steep areas. However, less space will be available for construction of buildings today.

CONCLUTION

This paper pioneered renewable and non-renewable energy. Here we will consider what should be done to maintain the cooling of a building during construction. There, by maintaining the cooling, the power is saved by using the energy to a minimum. Also, by analyzing the information by Mary R-Studio, errors were made.

Postgres SQL, Google Pro and QGIS software are used to solve other problems here. The primary objective here is to redevelop non-renewable energy. There, suitable area mapping for Sulan power plants in Sri Lanka will be done. Also, according to the energy produced by Suraya power plants, their spread across the country at the district level was also recorded. Also, a mapping of fuel consumption and the extent of petrol stations in Sri Lanka is done here.

Here, suitable areas for re-establishment of renewable energy are also marked. Here, suitable land for solar power plants and suitable land for solar power plants are marked on a map of Sri Lanka. Also, a suitable amount of land for the research center in the Kandy area is being used and digitization was done in relation to a part of the map that has been provided.

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