In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
```

In [2]:
```
df=pd.read_csv('task2.csv')
df.head(5)
```

Out[2]:

	ProjectSize	Budget	NumberOfWorkers	WeatherConditions	MaterialAvailability	TargetCompletionDate	D
0	554693.0	1431665.0	339.0	Sunny	Low	2023-08-05	
1	962240.0	1258378.0	383.0	Snowy	Medium	2023-02-21	
2	NaN	2799648.0	309.0	Sunny	Low	2025-04-04	
3	357638.0	3784610.0	57.0	Sunny	Low	2023-08-25	
4	442008.0	3173921.0	376.0	Rainy	Low	2024-12-18	

In [3]:
```
df.shape
```

Out[3]:
```
(10000, 17)
```

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 17 columns):
 #   Column                     Non-Null Count  Dtype  
---  ------                     --------------  -----  
 0   ProjectSize                9045 non-null   float64
 1   Budget                     9114 non-null   float64
 2   NumberOfWorkers            9072 non-null   float64
 3   WeatherConditions          9051 non-null   object 
 4   MaterialAvailability       9039 non-null   object 
 5   TargetCompletionDate       8998 non-null   object 
 6   Delayed                    10000 non-null  float64
 7   ProjectManagerExperience   9028 non-null   float64
 8   SubcontractorReliability   9090 non-null   object 
 9   RegulatoryApprovalStatus   9010 non-null   object 
 10  SiteAccessibility          9035 non-null   object 
 11  DailyWorkHours             9053 non-null   float64
 12  NumberOfSubcontractors     9025 non-null   float64
 13  ResourceAvailability       9043 non-null   object 
 14  ClientDemand               9072 non-null   object 
 15  EconomicConditions         9054 non-null   object 
 16  PreviousDelays             9044 non-null   float64
dtypes: float64(8), object(9)
memory usage: 1.3+ MB
```

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
ProjectSize                 955
Budget                      886
NumberOfWorkers             928
WeatherConditions           949
MaterialAvailability        961
TargetCompletionDate       1002
Delayed                       0
ProjectManagerExperience    972
SubcontractorReliability    910
RegulatoryApprovalStatus    990
SiteAccessibility           965
DailyWorkHours              947
NumberOfSubcontractors      975
ResourceAvailability        957
ClientDemand                928
EconomicConditions          946
PreviousDelays              956
dtype: int64
```

In [6]:
```
# ProjectSize
df['ProjectSize']=df.ProjectSize.fillna(df.ProjectSize.median()) # fill nans
```

In [7]:
```
df['ProjectSize']=sc.fit_transform(df[["ProjectSize"]]) # standerdization
```

In [8]:
```
# Budget
df["Budget"]=df.ProjectSize.fillna(df.ProjectSize.median()) # fill nans
```

In [9]:
```
df['Budget']=sc.fit_transform(df[["Budget"]]) # standerdization
```

In [10]:
```
# NumberOfWorkers
df['NumberOfWorkers']=df.NumberOfWorkers.fillna(df.NumberOfWorkers.mode()[0]) # fill nan
```

In [11]:
```
# WeatherConditions
df["WeatherConditions"]=df.WeatherConditions.fillna(df.WeatherConditions.mode()[0]) # fi
df.WeatherConditions.unique()
```

Out[11]:
```
array(['Sunny', 'Snowy', 'Rainy', 'Cloudy'], dtype=object)
```

In [12]:
```
WeatherConditions_dict=dict(df.WeatherConditions.value_counts()) # map with lables
```

In [13]:
```
df["WeatherConditions"]=df.WeatherConditions.map(WeatherConditions_dict)
```

In [14]:
```
# MaterialAvailability
df["MaterialAvailability"]=df.MaterialAvailability.fillna(df.MaterialAvailability.mode()
```

In [15]:
```
df.MaterialAvailability.value_counts()
```

Out[15]:
```
MaterialAvailability
Medium    4019
High      3024
Low       2957
Name: count, dtype: int64
```

In [16]:
```
df["MaterialAvailability"]=df.MaterialAvailability.map({"Low":1,"Medium":2,"High":3}) # 
```

In [17]:
```
#  TargetCompletionDate
df.drop('TargetCompletionDate',axis=1,inplace=True) # drop unwanted columns
```

In [18]:
```
# ProjectManagerExperience
df['ProjectManagerExperience']=df.ProjectManagerExperience.fillna(df.ProjectManagerExper
```

In [19]:
```
# SubcontractorReliability
df["SubcontractorReliability"]=df.SubcontractorReliability.fillna(df.SubcontractorReliab
```

In [20]:
```
df["SubcontractorReliability"].value_counts()
```

Out[20]:
```
SubcontractorReliability
Medium    3976
Low       3019
High      3005
Name: count, dtype: int64
```

In [21]:
```
df["SubcontractorReliability"]=df["SubcontractorReliability"].map({"Low":1,"Medium":2,"H
```

In [22]:
```
# RegulatoryApprovalStatus
df["RegulatoryApprovalStatus"]=df.RegulatoryApprovalStatus.fillna(df.RegulatoryApprovalS
```

In [23]:
```
df["RegulatoryApprovalStatus"].value_counts()
```

Out[23]:
```
RegulatoryApprovalStatus
Pending     4044
Rejected    2997
Approved    2959
Name: count, dtype: int64
```

In [24]:
```
df["RegulatoryApprovalStatus"]=df["RegulatoryApprovalStatus"].map({"Approved":2,"Rejecte
```

In [25]:
```
df["SiteAccessibility"]=df.SiteAccessibility.fillna(df.SiteAccessibility.mode()[0]) # fi
```

In [26]:
```
df.SiteAccessibility.value_counts()
```

Out[26]:
```
SiteAccessibility
Moderate    3995
Good        3009
Poor        2996
Name: count, dtype: int64
```

In [27]:
```
df["SiteAccessibility"]=df.SiteAccessibility.map({"Good":2,"Moderate":1,"Poor":0})
```

In [28]:
```
# DailyWorkHours
df["DailyWorkHours"]=df.DailyWorkHours.fillna(df.DailyWorkHours.mode()[0])
```

In [29]:
```
# NumberOfSubcontractors
df["NumberOfSubcontractors"]=df.NumberOfSubcontractors.fillna(df.NumberOfSubcontractors.
```

In [30]:
```
# ResourceAvailability
df["ResourceAvailability"]=df.ResourceAvailability.fillna(df.ResourceAvailability.mode()
```

In [31]:
```
df["ResourceAvailability"].value_counts()
```

Out[31]:
```
ResourceAvailability
High      4026
Low       2988
Medium    2986
Name: count, dtype: int64
```

In [32]:
```
df["ResourceAvailability"]=df["ResourceAvailability"].map({"Low":1,"Medium":2,"High":3})
```

In [33]:
```
# ClientDemand
df["ClientDemand"]=df.ClientDemand.fillna(df.ClientDemand.mode()[0])
```

In [34]:
```
df["ClientDemand"].value_counts()
```

Out[34]:
```
ClientDemand
Low       4019
High      3017
Medium    2964
Name: count, dtype: int64
```

In [35]:
```
df["ClientDemand"]=df["ClientDemand"].map({"Low":1,"Medium":2,"High":3}) # map with labl
```

In [36]:
```
# EconomicConditions
df["EconomicConditions"]=df.EconomicConditions.fillna(df.EconomicConditions.mode()[0])
```

In [37]:
```
df.EconomicConditions.value_counts()
```

Out[37]:
```
EconomicConditions
Unfavorable    4011
Neutral        3021
Favorable      2968
Name: count, dtype: int64
```

In [38]:
```
df["EconomicConditions"]=df["EconomicConditions"].map({"Unfavorable":0,"Neutral":1,"Favo
```

In [39]:
```
# PreviousDelays
df["PreviousDelays"]=df.PreviousDelays.fillna(df.PreviousDelays.mode()[0])
```

In [40]:
```
df.isnull().sum()
```

Out[40]:
```
ProjectSize                 0
Budget                      0
NumberOfWorkers             0
WeatherConditions           0
MaterialAvailability        0
Delayed                     0
ProjectManagerExperience    0
SubcontractorReliability    0
RegulatoryApprovalStatus    0
SiteAccessibility           0
DailyWorkHours              0
NumberOfSubcontractors      0
ResourceAvailability        0
ClientDemand                0
EconomicConditions          0
PreviousDelays              0
dtype: int64
```

In [41]:
```
df.head()
```

Out[41]:

	ProjectSize	Budget	NumberOfWorkers	WeatherConditions	MaterialAvailability	Delayed	ProjectManagerI
0	0.017920	0.017920	339.0	3286	1	1.0	
1	1.655336	1.655336	383.0	2156	2	0.0	
2	0.008864	0.008864	309.0	3286	1	0.0	
3	-0.773795	-0.773795	57.0	3286	1	0.0	
4	-0.434819	-0.434819	376.0	2274	1	0.0	

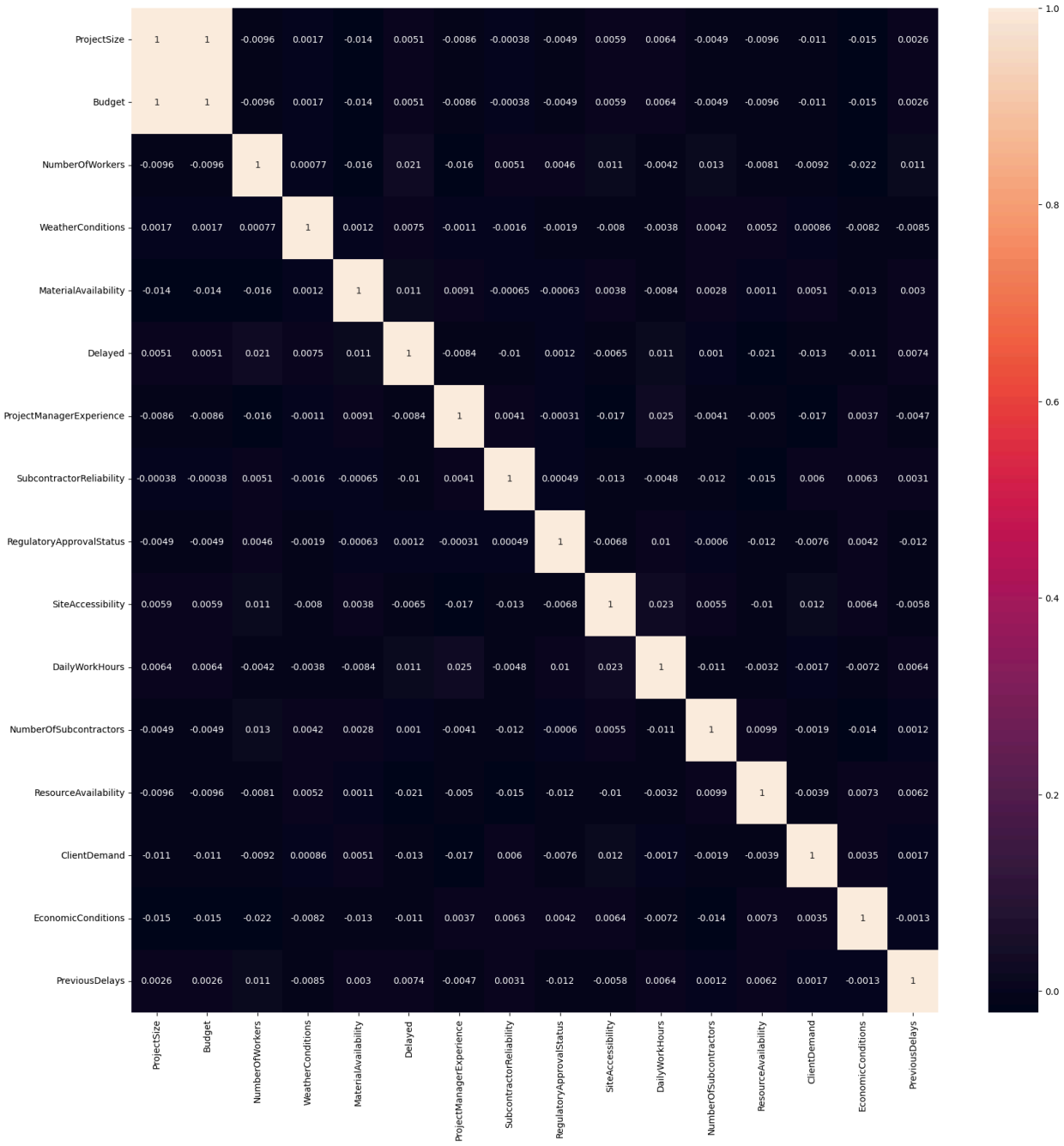
In [42]:
```
corr=df.corr()
corr
```

Out[42]:

	ProjectSize	Budget	NumberOfWorkers	WeatherConditions	MaterialAvailability	
ProjectSize	1.000000	1.000000	-0.009559	0.001711	-0.013803	
Budget	1.000000	1.000000	-0.009559	0.001711	-0.013803	
NumberOfWorkers	-0.009559	-0.009559	1.000000	0.000766	-0.016089	
WeatherConditions	0.001711	0.001711	0.000766	1.000000	0.001206	
MaterialAvailability	-0.013803	-0.013803	-0.016089	0.001206	1.000000	
Delayed	0.005136	0.005136	0.021319	0.007548	0.011119	
ProjectManagerExperience	-0.008639	-0.008639	-0.016154	-0.001118	0.009050	-
SubcontractorReliability	-0.000385	-0.000385	0.005091	-0.001627	-0.000651	-
RegulatoryApprovalStatus	-0.004949	-0.004949	0.004569	-0.001916	-0.000628	
SiteAccessibility	0.005919	0.005919	0.010688	-0.008040	0.003823	-
DailyWorkHours	0.006425	0.006425	-0.004162	-0.003804	-0.008435	
NumberOfSubcontractors	-0.004920	-0.004920	0.013284	0.004242	0.002790	
ResourceAvailability	-0.009583	-0.009583	-0.008077	0.005208	0.001096	-
ClientDemand	-0.011207	-0.011207	-0.009154	0.000858	0.005079	-
EconomicConditions	-0.014972	-0.014972	-0.021731	-0.008157	-0.013262	-
PreviousDelays	0.002566	0.002566	0.010929	-0.008453	0.003006	

In [43]:
```
plt.figure(figsize=(20,20))
sns.heatmap(corr,annot=True)
```

Out[43]: <Axes: >



In [45]:
```
# split x,y
X=df.drop("Delayed",axis=1)
y=df[["Delayed"]]
```

Feature selections

In [51]:
```
from sklearn.feature_selection import SelectKBest, f_classif
```

In [58]:
```
selector = SelectKBest(score_func=f_classif, k=10)
sc = selector.fit_transform(X,y)
selected_features = X.columns[selector.get_support()]
selected_features
```

```
C:\Users\USER\anaconda3\envs\python39\lib\site-packages\sklearn\utils\validation.py:133
9: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Pl
ease change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

Out[58]:
```
Index(['NumberOfWorkers', 'WeatherConditions', 'MaterialAvailability',
       'ProjectManagerExperience', 'SubcontractorReliability',
       'DailyWorkHours', 'ResourceAvailability', 'ClientDemand',
       'EconomicConditions', 'PreviousDelays'],
      dtype='object')
```

In [60]:
```
X_selected=X[selected_features]
```

In [72]:
```
# train test split
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X_selected,y,test_size=0.2,random_state=0
```

Model building

In [77]:
```
from sklearn.ensemble import RandomForestClassifier
rf=RandomForestClassifier()
rf.fit(X_train,y_train)
```

```
C:\Users\USER\anaconda3\envs\python39\lib\site-packages\sklearn\base.py:1473: DataConve
rsionWarning: A column-vector y was passed when a 1d array was expected. Please change
the shape of y to (n_samples,), for example using ravel().
  return fit_method(estimator, *args, **kwargs)
```

Out[77]:
```
RandomForestClassifier
RandomForestClassifier()
```
(https://scikit-learn.org/1.5/modules/generated/sklearn.ensemble.RandomForestClassifier

In [79]:
```
prediction=rf.predict(X_test)
```

In [80]:
```
from sklearn.metrics import classification_report
```

In [82]:
```
print(classification_report(prediction,y_test))
```

```
              precision    recall  f1-score   support

         0.0       0.97      0.70      0.82      1935
         1.0       0.04      0.35      0.07        65

    accuracy                           0.69      2000
   macro avg       0.50      0.53      0.44      2000
weighted avg       0.94      0.69      0.79      2000
```

In [ ]:

In [ ]:

In [ ]: