# project

December 21, 2021

[224]:

```
# Importing necessary modules.
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
import statsmodels.api as sm
import scipy.stats as stats
from scipy import stats
from sklearn import set_config

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import OneHotEncoder , StandardScaler
from sklearn.preprocessing import OrdinalEncoder , LabelEncoder
from sklearn.impute import SimpleImputer

from sklearn.linear_model import LogisticRegression
from sklearn.datasets import make_regression
from sklearn.ensemble import RandomForestClassifier, VotingClassifier
from sklearn.ensemble import GradientBoostingClassifier
from xgboost import XGBClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.pipeline import Pipeline, FeatureUnion
from sklearn.compose import ColumnTransformer
from sklearn.dummy import DummyClassifier
from sklearn.tree import export_graphviz, plot_tree
from IPython.display import Image
from sklearn.metrics import precision_score
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import cross_val_score

from sklearn import preprocessing
from sklearn.metrics import mean_squared_error, make_scorer
import sklearn.metrics as metrics
from sklearn.metrics import r2_score
from sklearn.metrics import plot_confusion_matrix, classification_report
from sklearn.metrics import confusion_matrix
set_config(display='diagram')
```

## 0.1 Business Value

Tanzania is currently a 62million population country. And still doesn't have enough well water resources for some of peoples in the country. Water is the basic needs for human body. Tanzania Government is currently working for solve this problem by improving clean water sources.There are many water wells already established, but some of them are non-functional or needs repair.

## 0.2 Business Problem

In this model, our aim is the predict **functionality** of water points. This will help Tanzania Government for future work. If a water point needs repair or why is not functional and what features affect functionality. With this model, we can help the Tanzanian authorities how to use water sources in a productive way.

[225]:

```
# Import and looking the data.
train_data = pd.read_csv('train_data.csv')
test_data = pd.read_csv('test_data.csv')
train_data.head()
```

[225]:

```
      id  amount_tsh date_recorded       funder  gps_height     installer  \
0  69572      6000.0    2011-03-14        Roman        1390         Roman
1   8776         0.0    2013-03-06      Grumeti        1399       GRUMETI
2  34310        25.0    2013-02-25 Lottery Club         686  World vision
3  67743         0.0    2013-01-28       Unicef         263        UNICEF
4  19728         0.0    2011-07-13  Action In A           0       Artisan

   longitude   latitude              wpt_name  num_private  … payment_type  \
0  34.938093  -9.856322                  none            0  …     annually
1  34.698766  -2.147466              Zahanati            0  …    never pay
2  37.460664  -3.821329           Kwa Mahundi            0  …   per bucket
3  38.486161 -11.155298  Zahanati Ya Nanyumbu            0  …    never pay
4  31.130847  -1.825359               Shuleni            0  …    never pay

  water_quality quality_group      quantity  quantity_group  \
0          soft          good        enough          enough
1          soft          good  insufficient    insufficient
2          soft          good        enough          enough
3          soft          good           dry             dry
4          soft          good      seasonal        seasonal

                 source           source_type  source_class  \
0                spring                spring   groundwater
1  rainwater harvesting  rainwater harvesting       surface
2                   dam                   dam       surface
```

```
3           machine dbh              borehole   groundwater
4  rainwater harvesting  rainwater harvesting       surface

               waterpoint_type waterpoint_type_group
0           communal standpipe    communal standpipe
1           communal standpipe    communal standpipe
2  communal standpipe multiple    communal standpipe
3  communal standpipe multiple    communal standpipe
4           communal standpipe    communal standpipe

[5 rows x 40 columns]
```

[226]:
```
# Importing labels as our target variable.
labels = pd.read_csv('train_labels.csv')
labels
```

[226]:
```
          id    status_group
0      69572      functional
1       8776      functional
2      34310      functional
3      67743  non functional
4      19728      functional
…        …             …
59395  60739      functional
59396  27263      functional
59397  37057      functional
59398  31282      functional
59399  26348      functional

[59400 rows x 2 columns]
```

[227]:
```
#Looking our data.
train_data.describe()
```

[227]:
```
                 id     amount_tsh    gps_height     longitude      latitude  \
count  59400.000000   59400.000000  59400.000000  59400.000000  5.940000e+04
mean   37115.131768     317.650385    668.297239     34.077427 -5.706033e+00
std    21453.128371    2997.574558    693.116350      6.567432  2.946019e+00
min        0.000000       0.000000    -90.000000      0.000000 -1.164944e+01
25%    18519.750000       0.000000      0.000000     33.090347 -8.540621e+00
50%    37061.500000       0.000000    369.000000     34.908743 -5.021597e+00
75%    55656.500000      20.000000   1319.250000     37.178387 -3.326156e+00
max    74247.000000  350000.000000   2770.000000     40.345193 -2.000000e-08

        num_private   region_code  district_code    population  \
count  59400.000000  59400.000000   59400.000000  59400.000000
mean       0.474141     15.297003       5.629747    179.909983
```

```
std       12.236230     17.587406      9.633649    471.482176
min        0.000000      1.000000      0.000000      0.000000
25%        0.000000      5.000000      2.000000      0.000000
50%        0.000000     12.000000      3.000000     25.000000
75%        0.000000     17.000000      5.000000    215.000000
max     1776.000000     99.000000     80.000000  30500.000000

       construction_year
count       59400.000000
mean         1300.652475
std           951.620547
min             0.000000
25%             0.000000
50%          1986.000000
75%          2004.000000
max          2013.000000
```

[228]:

```
#Looking inside features.(what kind of column with the column names and missing␣
 ↪values)
train_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 59400 entries, 0 to 59399
Data columns (total 40 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   id                     59400 non-null  int64
 1   amount_tsh             59400 non-null  float64
 2   date_recorded          59400 non-null  object
 3   funder                 55765 non-null  object
 4   gps_height             59400 non-null  int64
 5   installer              55745 non-null  object
 6   longitude              59400 non-null  float64
 7   latitude               59400 non-null  float64
 8   wpt_name               59400 non-null  object
 9   num_private            59400 non-null  int64
 10  basin                  59400 non-null  object
 11  subvillage             59029 non-null  object
 12  region                 59400 non-null  object
 13  region_code            59400 non-null  int64
 14  district_code          59400 non-null  int64
 15  lga                    59400 non-null  object
 16  ward                   59400 non-null  object
 17  population             59400 non-null  int64
 18  public_meeting         56066 non-null  object
 19  recorded_by            59400 non-null  object
 20  scheme_management      55523 non-null  object
 21  scheme_name            31234 non-null  object
 22  permit                 56344 non-null  object
 23  construction_year      59400 non-null  int64
 24  extraction_type        59400 non-null  object
 25  extraction_type_group  59400 non-null  object
 26  extraction_type_class  59400 non-null  object
 27  management             59400 non-null  object
 28  management_group       59400 non-null  object
 29  payment                59400 non-null  object
 30  payment_type           59400 non-null  object
 31  water_quality          59400 non-null  object
 32  quality_group          59400 non-null  object
 33  quantity               59400 non-null  object
 34  quantity_group         59400 non-null  object
 35  source                 59400 non-null  object
 36  source_type            59400 non-null  object
 37  source_class           59400 non-null  object
 38  waterpoint_type        59400 non-null  object
 39  waterpoint_type_group  59400 non-null  object
dtypes: float64(3), int64(7), object(30)
memory usage: 18.1+ MB
```

### 0.3 Data Understanding

Our data has 39 different columns as feature include 'id'. Some of them has missing values and

We have data from 1960 to 2013 with different funders at 21 different regions in Tanzania. And

We have quantity of the water source with source type as spring, shallow well etc.

We are going to more focus data understanding as looking inside every column.

[229]:
```python
# Merging target and features.
train_data = train_data.merge(labels,on='id')
train_data
```

[229]:
```
          id  amount_tsh date_recorded          funder  gps_height  \
0      69572      6000.0    2011-03-14           Roman        1390
1       8776         0.0    2013-03-06         Grumeti        1399
2      34310        25.0    2013-02-25    Lottery Club         686
3      67743         0.0    2013-01-28          Unicef         263
4      19728         0.0    2011-07-13     Action In A           0
…        …           …           …               …           …
59395  60739        10.0    2013-05-03  Germany Republi        1210
59396  27263      4700.0    2011-05-07     Cefa-njombe        1212
59397  37057         0.0    2011-04-11             NaN           0
59398  31282         0.0    2011-03-08           Malec           0
59399  26348         0.0    2011-03-23      World Bank         191
```

```
          installer  longitude   latitude             wpt_name  num_private  \
0             Roman  34.938093  -9.856322                 none            0
1           GRUMETI  34.698766  -2.147466             Zahanati            0
2      World vision  37.460664  -3.821329          Kwa Mahundi            0
3            UNICEF  38.486161 -11.155298  Zahanati Ya Nanyumbu            0
4           Artisan  31.130847  -1.825359              Shuleni            0
…             …        …        …                   …          …
59395           CES  37.169807  -3.253847   Area Three Namba 27            0
59396          Cefa  35.249991  -9.070629     Kwa Yahona Kuvala            0
59397           NaN  34.017087  -8.750434               Mashine            0
59398          Musa  35.861315  -6.378573                Mshoro            0
59399         World  38.104048  -6.747464       Kwa Mzee Lugawa            0

       … water_quality quality_group      quantity  quantity_group  \
0      …          soft          good        enough          enough
1      …          soft          good  insufficient    insufficient
2      …          soft          good        enough          enough
3      …          soft          good           dry             dry
4      …          soft          good      seasonal        seasonal
…    …           …           …           …             …
59395  …          soft          good        enough          enough
59396  …          soft          good        enough          enough
59397  …      fluoride      fluoride        enough          enough
59398  …          soft          good  insufficient    insufficient
59399  …         salty         salty        enough          enough

                     source           source_type source_class  \
0                    spring                spring  groundwater
1      rainwater harvesting  rainwater harvesting      surface
2                       dam                   dam      surface
3               machine dbh              borehole  groundwater
4      rainwater harvesting  rainwater harvesting      surface
…                     …                   …          …
59395                spring                spring  groundwater
59396                 river            river/lake      surface
59397           machine dbh              borehole  groundwater
59398          shallow well          shallow well  groundwater
59399          shallow well          shallow well  groundwater

                   waterpoint_type waterpoint_type_group    status_group
0               communal standpipe    communal standpipe      functional
1               communal standpipe    communal standpipe      functional
2      communal standpipe multiple    communal standpipe      functional
3      communal standpipe multiple    communal standpipe  non functional
4               communal standpipe    communal standpipe      functional
…                            …                   …             …
59395           communal standpipe    communal standpipe      functional
```

```
59396         communal standpipe    communal standpipe      functional
59397                  hand pump             hand pump      functional
59398                  hand pump             hand pump      functional
59399                  hand pump             hand pump      functional

[59400 rows x 41 columns]
```

## 0.4 Cleaning Process

### 0.4.1 Train Data Cleaning

[230]:

```
#Looking for missing values.
train_data.isna().sum()
```

[230]:

```
id                           0
amount_tsh                   0
date_recorded                0
funder                    3635
gps_height                   0
installer                 3655
longitude                    0
latitude                     0
wpt_name                     0
num_private                  0
basin                        0
subvillage                 371
region                       0
region_code                  0
district_code                0
lga                          0
ward                         0
population                   0
public_meeting            3334
recorded_by                  0
scheme_management         3877
scheme_name              28166
permit                    3056
construction_year            0
extraction_type              0
extraction_type_group        0
extraction_type_class        0
management                   0
management_group             0
payment                      0
payment_type                 0
water_quality                0
quality_group                0
```

```
quantity                     0
quantity_group               0
source                       0
source_type                  0
source_class                 0
waterpoint_type              0
waterpoint_type_group        0
status_group                 0
dtype: int64
```

[231]:

```
# Turning target column from ternary to binary.
train_data['status_group'] = train_data['status_group'].replace('functional␣
↪needs repair','non functional')
```

[232]:

```
# Checking target variable values.
train_data['status_group'].value_counts()
```

[232]:

```
functional        32259
non functional    27141
Name: status_group, dtype: int64
```

[233]:

```
# Filling some columns as feature engineering.
train_data['funder'].fillna('Unkown',inplace=True)
train_data['funder'].replace(to_replace = '0', value ='Unknown' , inplace=True)

train_data['installer'].fillna('Unkown',inplace=True)

train_data['subvillage'].fillna('Missing',inplace=True)
train_data['public_meeting'].fillna(False,inplace=True)
```

[234]:

```
# Looking inside scheme management column.
train_data['scheme_management'].value_counts()
```

[234]:

```
VWC                  36793
WUG                   5206
Water authority       3153
WUA                   2883
Water Board           2748
Parastatal            1680
Private operator      1063
Company               1061
Other                  766
SWC                     97
Trust                   72
None                     1
Name: scheme_management, dtype: int64
```

[235]:

```
# Filling scheme management column.
train_data['scheme_management'].fillna('Missing',inplace=True)
```

[236]:

```
# Filling permit column.
train_data['permit'].fillna(False,inplace=True)
```

[237]:

```
# Boolean column converting process.
le = preprocessing.LabelEncoder()
train_data['public_meeting'] = le.fit_transform(train_data.public_meeting.
 ↪values)
train_data['permit'] = le.fit_transform(train_data.permit.values)
train_data.dtypes
```

[237]:

```
id                         int64
amount_tsh               float64
date_recorded             object
funder                    object
gps_height                 int64
installer                 object
longitude                float64
latitude                 float64
wpt_name                  object
num_private                int64
basin                     object
subvillage                object
region                    object
region_code                int64
district_code              int64
lga                       object
ward                      object
population                 int64
public_meeting             int64
recorded_by               object
scheme_management         object
scheme_name               object
permit                     int64
construction_year          int64
extraction_type           object
extraction_type_group     object
extraction_type_class     object
management                object
management_group          object
payment                   object
payment_type              object
water_quality             object
quality_group             object
quantity                  object
```

```
 quantity_group           object
 source                   object
 source_type              object
 source_class             object
 waterpoint_type          object
 waterpoint_type_group    object
 status_group             object
 dtype: object
```

### 0.4.2 Looking Inside Each Column

```
Column Names

amount_tsh - Total static head (amount water available to waterpoint)
date_recorded - The date the row was entered
funder - Who funded the well
gps_height - Altitude of the well
installer - Organization that installed the well
longitude - GPS coordinate
latitude - GPS coordinate
wpt_name - Name of the waterpoint if there is one
num_private -
basin - Geographic water basin
subvillage - Geographic location
region - Geographic location
region_code - Geographic location (coded)
district_code - Geographic location (coded)
lga - Geographic location
ward - Geographic location
population - Population around the well
public_meeting - True/False
recorded_by - Group entering this row of data
scheme_management - Who operates the waterpoint
scheme_name - Who operates the waterpoint
permit - If the waterpoint is permitted
construction_year - Year the waterpoint was constructed
extraction_type - The kind of extraction the waterpoint uses
extraction_type_group - The kind of extraction the waterpoint uses
extraction_type_class - The kind of extraction the waterpoint uses
management - How the waterpoint is managed
management_group - How the waterpoint is managed
payment - What the water costs
payment_type - What the water costs
water_quality - The quality of the water
quality_group - The quality of the water
quantity - The quantity of water
quantity_group - The quantity of water
source - The source of the water
```

```
source_type - The source of the water
source_class - The source of the water
waterpoint_type - The kind of waterpoint
waterpoint_type_group - The kind of waterpoint
```

### Amount_tsh Column

[238]:

```
train_data['amount_tsh'].value_counts()
```

[238]:

```
0.0         41639
500.0        3102
50.0         2472
1000.0       1488
20.0         1463
            …
8500.0          1
6300.0          1
220.0           1
138000.0        1
12.0            1
Name: amount_tsh, Length: 98, dtype: int64
```

[239]:

```
# Defining function for feature engineering on amount column.
def split_amount(amount):
    if amount < 10:
        return 'Less amount water source at this point.'
    return 'Enough amount water source at this point.'
```

[240]:

```
#Applying function to this column.
train_data['amount_tsh'] = train_data['amount_tsh'].apply(split_amount)
```

[241]:

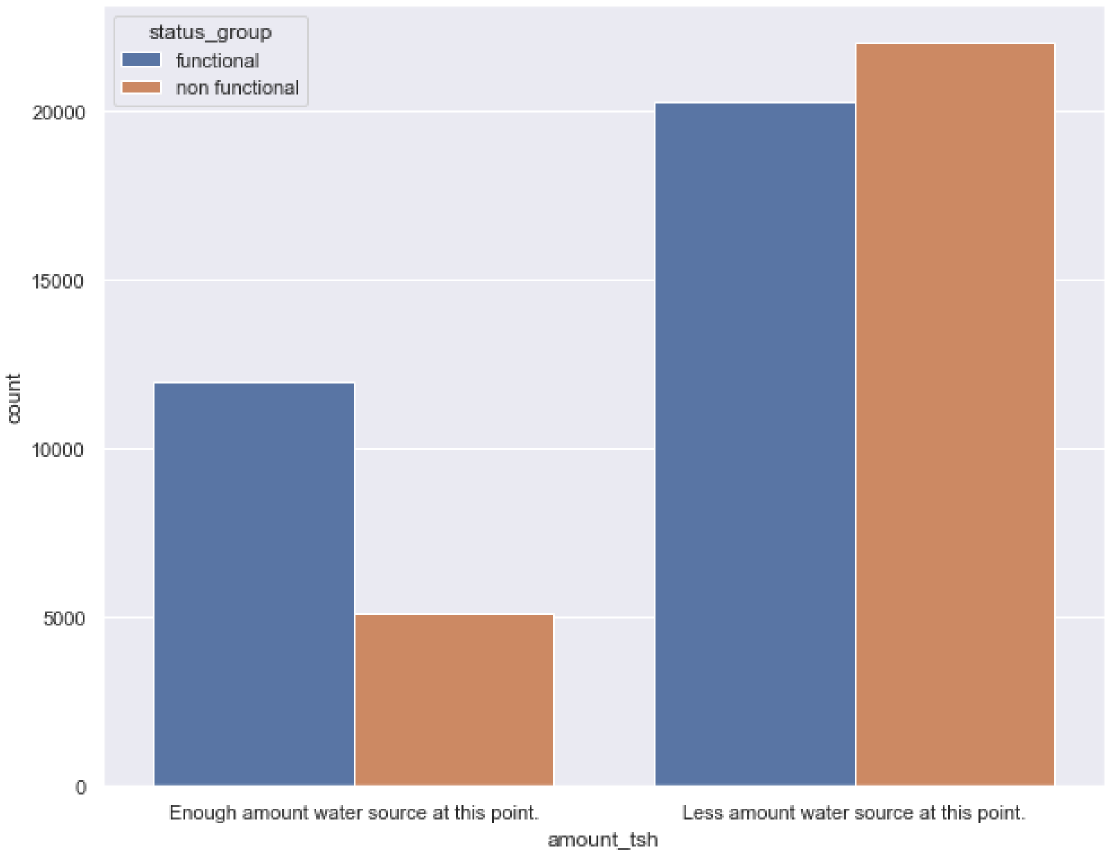
```
train_data['amount_tsh'].value_counts()
```

[241]:

```
Less amount water source at this point.      42295
Enough amount water source at this point.    17105
Name: amount_tsh, dtype: int64
```

[242]:

```
# Creating visualizing for this column with functionality.
sns.set_theme(style="darkgrid")
fig, ax = plt.subplots(figsize=(10,8))
ax = sns.countplot(x='amount_tsh', hue="status_group", data=train_data )
```



**If water point has enough source , there seems to be likely functional , on the other hand if there is not enough water source at the point almost half of them functional.**

### Date Recorded Column

[243]:
```python
# Feature engineering in date recorded column.
years = []
for i in train_data.date_recorded:
    years.append(i[:4])
```

[244]:
```python
train_data['date_recorded'] = years
```

[245]:
```python
# For date column we are going to use just 'years'.
```

[246]:
```python
train_data['date_recorded'].value_counts()
```

[246]:
```
2011    28674
2013    24271
2012     6424
2004       30
2002        1
```

```
Name: date_recorded, dtype: int64
```

[247]:
```
# Replacing outliers with other less value.
train_data['date_recorded'].replace('2002','2012',inplace=True)
train_data['date_recorded'].replace('2004','2012',inplace=True)
```

[248]:
```
train_data['date_recorded'].value_counts()
```

[248]:
```
2011    28674
2013    24271
2012     6455
Name: date_recorded, dtype: int64
```

### Funder Column

[249]:
```
train_data.funder.value_counts()
```

[249]:
```
Government Of Tanzania        9084
Unkown                        3635
Danida                        3114
Hesawa                        2202
Rwssp                         1374
                              …
Tanedaps Society                 1
Dwe/ubalozi Wa Marekani          1
Noeli Mahobokela                 1
Deogratius Kasima                1
Muslimehefen International       1
Name: funder, Length: 1897, dtype: int64
```

[250]:
```
funders = train_data['funder']
```

[251]:
```
# Changing values at the funder column.
train_data.loc[train_data['funder']
               .value_counts()
               [train_data['funder']]
               .values < 201, 'funder'] = "Others"
```

[252]:
```
train_data['funder'].value_counts()
```

[252]:
```
Others                            18842
Government Of Tanzania             9084
Unkown                             3635
Danida                             3114
Hesawa                             2202
Rwssp                              1374
World Bank                         1349
Kkkt                               1287
```

```
World Vision                       1246
Unicef                             1057
Tasaf                               877
District Council                    843
Dhv                                 829
Private Individual                  826
Dwsp                                811
Unknown                             781
Norad                               765
Germany Republi                     610
Tcrs                                602
Ministry Of Water                   590
Water                               583
Dwe                                 484
Netherlands                         470
Hifab                               450
Adb                                 448
Lga                                 442
Amref                               425
Fini Water                          393
Oxfam                               359
Wateraid                            333
Rc Church                           321
Isf                                 316
Rudep                               312
Mission                             301
Private                             295
Jaica                               280
Roman                               275
Rural Water Supply And Sanitat      270
Adra                                263
Ces(gmbh)                           260
Jica                                259
Shipo                               241
Wsdp                                234
Rc                                  230
Finw                                219
Dh                                  213
Name: funder, dtype: int64
```

### Gps_height Column

[253]:

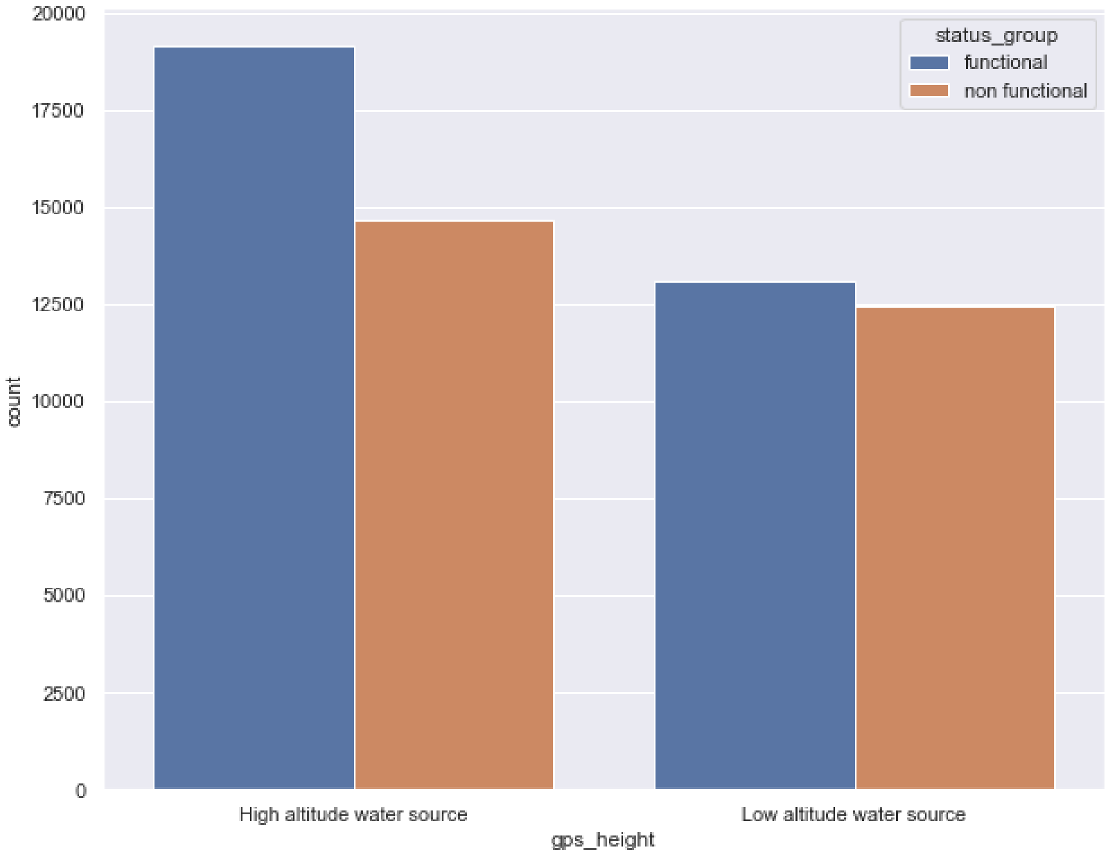
```
# Creating function for gps column seperation.
def split_gps(gps):
    if gps < 200:
        return 'Low altitude water source'
    if gps >= 200:
        return 'High altitude water source'
```

```
[254]: train_data['gps_height'] = train_data['gps_height'].apply(split_gps)
```

```
[255]: # Checking this column values.
       train_data.gps_height.value_counts(normalize=True)
```

```
[255]: High altitude water source    0.569579
       Low altitude water source     0.430421
       Name: gps_height, dtype: float64
```

```
[256]: # Craeting graph for gps height with functionality.
       fig, ax = plt.subplots(figsize=(10,8))
       ax = sns.countplot(x='gps_height', hue="status_group", data=train_data )
```



It tend to be at the high altitude more functional likely. At the low altitude looks like even functional and non functional water points.

### Installer Column

[257]:
```
train_data.installer.value_counts()
```

[257]:
```
DWE                  17402
Unkown                3655
Government            1825
RWE                   1206
Commu                 1060
                     …
MSIKITI                  1
LEI                      1
Busoga trust             1
Luali Kaima              1
Government /SDA          1
Name: installer, Length: 2146, dtype: int64
```

[258]:
```
# Changing values at the intaller column.
train_data.loc[train_data['installer']
               .value_counts()
               [train_data['installer']]
               .values  > 1001, 'installer'] = "Above 1000 water point␣
 ↪installers."
```

[259]:
```
# Changing values at the installer column.
train_data.loc[train_data['installer']
               .value_counts()
               [train_data['installer']]
               .values < 100, 'installer'] = "Under 100 water point installers."
```

[260]:
```
# Changing values at the installer column.
train_data.loc[train_data['installer']
               .value_counts()
               [train_data['installer']]
               .values < 1000, 'installer'] = "Under 1000 water point␣
 ↪installers."
```

[261]:
```
# Checking installer column values.
train_data.installer.value_counts()
```

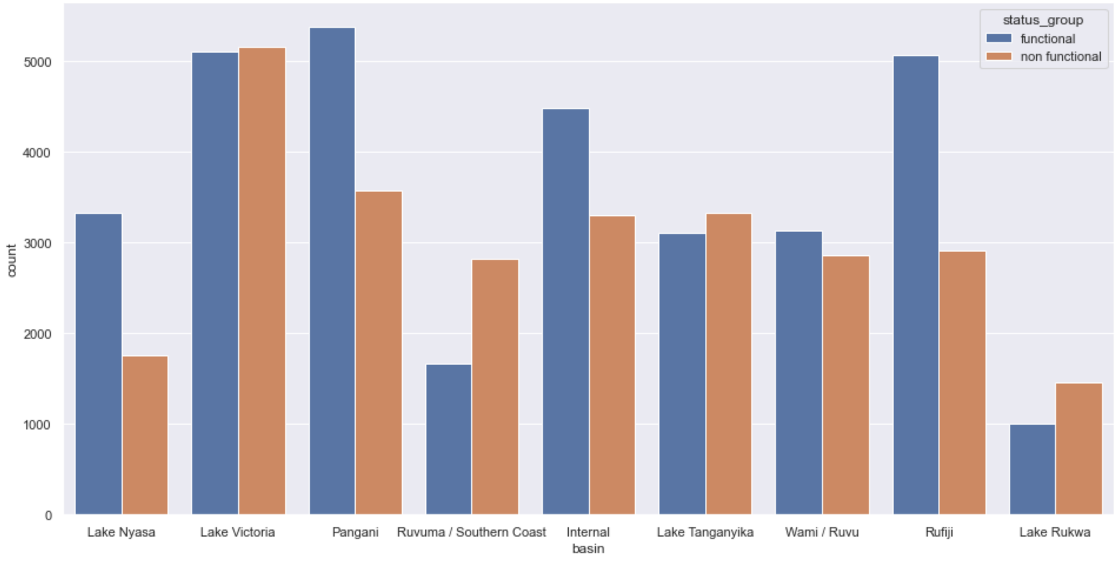
[261]:
```
Above 1000 water point installers.    26198
Under 1000 water point installers.    19657
Under 100 water point installers.     13545
Name: installer, dtype: int64
```

### Basin Column

[262]:
```
train_data.basin.value_counts()
```

[262]:
```
Lake Victoria              10248
Pangani                     8940
Rufiji                      7976
Internal                    7785
Lake Tanganyika             6432
Wami / Ruvu                 5987
Lake Nyasa                  5085
Ruvuma / Southern Coast     4493
Lake Rukwa                  2454
Name: basin, dtype: int64
```

[263]:
```
# Creating graph for basin column with functionality.
fig, ax = plt.subplots(figsize=(16,8))
ax = sns.countplot(x='basin', hue="status_group", data=train_data)
```



### Subvillage Column

[264]:
```
train_data['subvillage'].value_counts()
```

[264]:
```
Madukani      508
Shuleni       506
Majengo       502
Kati          373
Missing       371
             …
Matakuja        1
Nyamuko         1
Salaliya        1
Hongi Juu       1
```

```
Wami            1
Name: subvillage, Length: 19288, dtype: int64
```

[265]:

```
# Feature engineering on subvillage column.
train_data.loc[train_data['subvillage']
               .value_counts()
               [train_data['subvillage']]
               .values  > 100]
```

[265]:

```
          id                               amount_tsh date_recorded  \
2      34310  Enough amount water source at this point.          2013
20     48375  Enough amount water source at this point.          2011
26     55012  Enough amount water source at this point.          2013
42     52019  Enough amount water source at this point.          2011
70     21990  Enough amount water source at this point.          2011
…      …                                           …           …
59358  44951  Enough amount water source at this point.          2011
59365   8810    Less amount water source at this point.          2011
59369  47527    Less amount water source at this point.          2011
59384  72148    Less amount water source at this point.          2011
59385  34473  Enough amount water source at this point.          2012

                       funder                  gps_height  \
2                      Others  High altitude water source
20                     Others  High altitude water source
26                     Others  High altitude water source
42                     Others  High altitude water source
70     Government Of Tanzania  High altitude water source
…                        …                          …
59358                  Unicef  High altitude water source
59365                  Unicef  High altitude water source
59369               Rc Church   Low altitude water source
59384                  Others   Low altitude water source
59385                   Jaica  High altitude water source

                                installer  longitude  latitude  \
2      Under 1000 water point installers.  37.460664 -3.821329
20     Under 1000 water point installers.  34.473430 -9.594990
26      Under 100 water point installers.  39.370777 -9.942532
42      Under 100 water point installers.  34.814574 -9.032503
70     Above 1000 water point installers.  35.818981 -8.934950
…                                    …        …       …
59358  Above 1000 water point installers.  34.631938 -8.723208
59365  Above 1000 water point installers.  34.594790 -9.072904
59369   Under 100 water point installers.  33.670049 -9.001535
59384   Under 100 water point installers.  30.667805 -2.483710
59385   Under 100 water point installers.  33.951681 -2.021854
```

```
                    wpt_name  num_private  … water_quality quality_group  \
2                Kwa Mahundi            0  …          soft          good
20                      none            0  …          soft          good
26     Ruhoma Primary School            0  …          soft          good
42         Zahanati-Misssion            0  …          soft          good
70               Kwampalanji            0  …       unknown       unknown
…                      …          …  …           …           …
59358      Kwa Helena Mabena            0  …          soft          good
59365      Kwa Yohane Mhanza            0  …          soft          good
59369        Kwa Paval Dinno            0  …          soft          good
59384               Chamkube            0  …          soft          good
59385            Kwa Marunda            0  …         salty         salty

           quantity quantity_group        source   source_type source_class  \
2            enough         enough           dam           dam      surface
20           enough         enough        spring        spring  groundwater
26           enough         enough   machine dbh      borehole  groundwater
42           enough         enough        spring        spring  groundwater
70     insufficient   insufficient  shallow well  shallow well  groundwater
…             …             …           …           …          …
59358        enough         enough         river    river/lake      surface
59365        enough         enough         river    river/lake      surface
59369        enough         enough         river    river/lake      surface
59384  insufficient   insufficient        spring        spring  groundwater
59385        enough         enough   machine dbh      borehole  groundwater

                   waterpoint_type  waterpoint_type_group    status_group
2      communal standpipe multiple     communal standpipe      functional
20              communal standpipe     communal standpipe      functional
26                       hand pump              hand pump      functional
42              communal standpipe     communal standpipe      functional
70                       hand pump              hand pump  non functional
…                            …                    …             …
59358           communal standpipe     communal standpipe      functional
59365           communal standpipe     communal standpipe  non functional
59369           communal standpipe     communal standpipe      functional
59384           communal standpipe     communal standpipe  non functional
59385                    hand pump              hand pump      functional

[4841 rows x 41 columns]
```

### Region Column

[283]:

```
train_data['region'].value_counts()
```

[283]:

```
Iringa           5294
Shinyanga        4982
```

```
Mbeya            4639
Kilimanjaro      4379
Morogoro         4006
Arusha           3350
Kagera           3316
Mwanza           3102
Kigoma           2816
Ruvuma           2640
Pwani            2635
Tanga            2547
Dodoma           2201
Singida          2093
Mara             1969
Tabora           1959
Rukwa            1808
Mtwara           1730
Manyara          1583
Lindi            1546
Dar es Salaam     805
Name: region, dtype: int64
```

[310]:

```
sorted_region = train_data['population'].groupby(train_data['region']).sum().
 ↪sort_values()
```

[317]:

```
train_data['population'].groupby(train_data['region']).sum()
```

[317]:

```
region
Arusha            878782
Dar es Salaam     193879
Dodoma            618481
Iringa            826331
Kagera            931796
Kigoma           1417392
Kilimanjaro       463070
Lindi             563370
Manyara           503043
Mara             1060886
Mbeya            1303559
Morogoro         1060090
Mtwara            462674
Mwanza            971145
Pwani             921177
Rukwa             674566
Ruvuma            656638
Shinyanga        1424109
Singida           584765
Tabora            550479
```

```
Tanga             628482
Name: population, dtype: int64
```

[321]:
```
grouped_region
```

[321]:
```
           region         id            longitude             latitude  \
17      Shinyanga  182679138           132,195.96           -13,902.38
5          Kigoma  102667532            85,084.53           -12,098.15
10          Mbeya  174055235           155,552.65           -42,202.92
9            Mara   74861850            67,249.11            -3,425.87
11       Morogoro  148280588           148,405.91           -29,690.72
13         Mwanza  116488810            75,945.14            -6,014.05
4          Kagera  123713407           103,569.50            -6,504.22
14          Pwani   97304169           102,445.97           -18,471.23
0          Arusha  125452610           122,451.59           -10,875.62
3          Iringa  194159068           184,739.36           -47,157.36
15          Rukwa   67564706            56,562.17           -13,305.58
16         Ruvuma   99180138            94,325.36           -28,444.36
20          Tanga   94829204            98,076.07           -12,915.49
2          Dodoma   80760619            79,333.22           -13,049.14
18        Singida   76474025            72,714.67           -10,265.46
7           Lindi   57574121            60,289.53           -15,113.21
19         Tabora   72555411            64,415.02            -9,251.57
8         Manyara   59102904            56,881.80            -6,785.07
6     Kilimanjaro  163126393           164,234.87           -15,426.44
12         Mtwara   63791546            68,157.98           -18,477.19
1   Dar es Salaam   30017353            31,568.72            -5,562.29

    num_private  region_code  district_code  population  public_meeting  \
17            0        84598          17785     1424109            3761
5             0        45056           5597     1417392            2663
10            0        55668          19941     1303559            3914
9            73        39380           6031     1060886             794
11          426        20030          12141     1060090            3861
13            0        58828          12550      971145            2695
4             0        59688          28869      931796            3277
14         3190        71162          52289      921177            2234
0            32        13872          22636      878782            3075
3            63        58234          18893      826331            5012
15            0        27120           3725      674566            1419
16          905        26400           7931      656638            1897
20        16298        10222           9211      628482            2362
2             0         2201           6493      618481            2192
18          137        27209           4373      584765            1908
7            10       101584          41540      563370            1072
19            0        27426           5583      550479            1397
8            57        33243           4023      503043            1506
```

```
6         6520     13137        15956      463070          3961
12         453    127917        37108      462674          1672
1            0      5635         1732      193879           339

    permit  construction_year
17    2364             328430
5     1656            5606470
10    2134                  0
9      998            3899032
11    3967            7960149
13    2975             707888
4     2521                  0
14    1530            4925027
0     2650            6594069
3     3174            9831406
15    1162            3593685
16    1798            5241299
20    1378            4887905
2      989                  0
18     805            4158195
7      813            2858609
19    1325                  0
8     1506            3143319
6     3796            8672984
12    1311            3273470
1        0            1576820
```

[323]:

```python
grouped_region = train_data.groupby('region').sum().reset_index()
grouped_region.sort_values(by='population',ascending=True,inplace=True)
```

[365]:

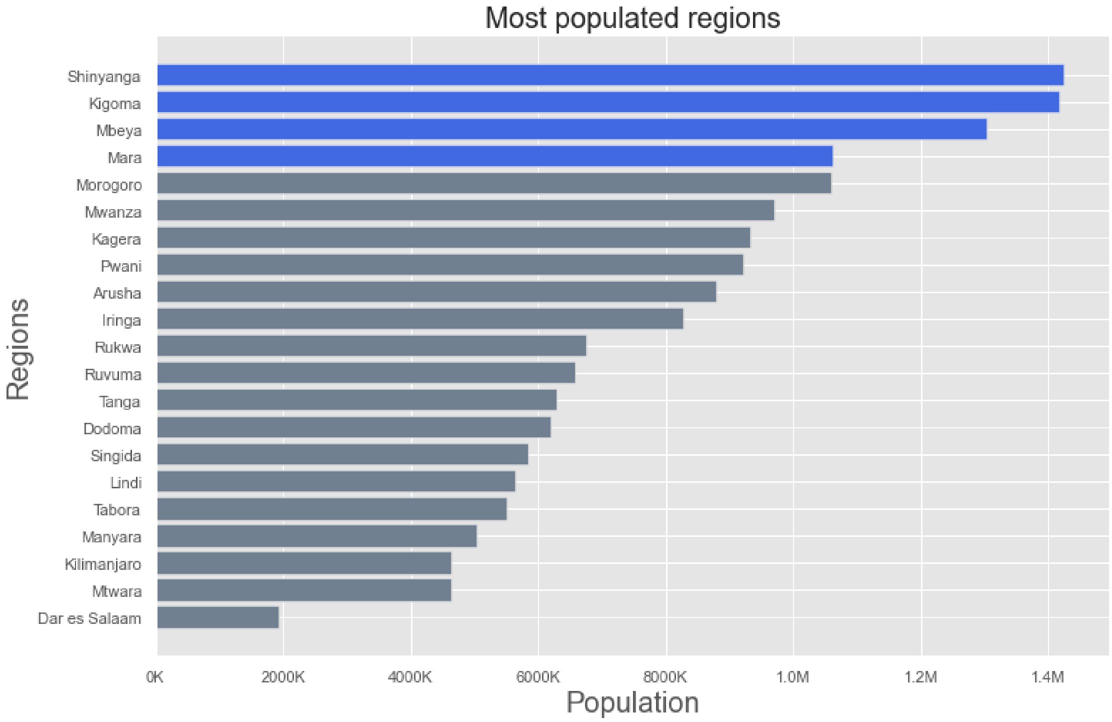
```python
#Creating function to fix scientific notations.
def notation(x, pos):
    """The two args are the value and tick position"""
    if x >= 1e6:
        s = '{:1.1f}M'.format(x*1e-6)
    else:
        s = '{:1.0f}K'.format(x*1e-2)
    return s
```

[366]:

```python
#Creating visual for region populations.
colors=[]
for region in grouped_region['region']:
    if (
        (region=='Shinyanga') or
        (region=='Kigoma') or
        (region=='Mbeya')or
        (region=='Mara')
```

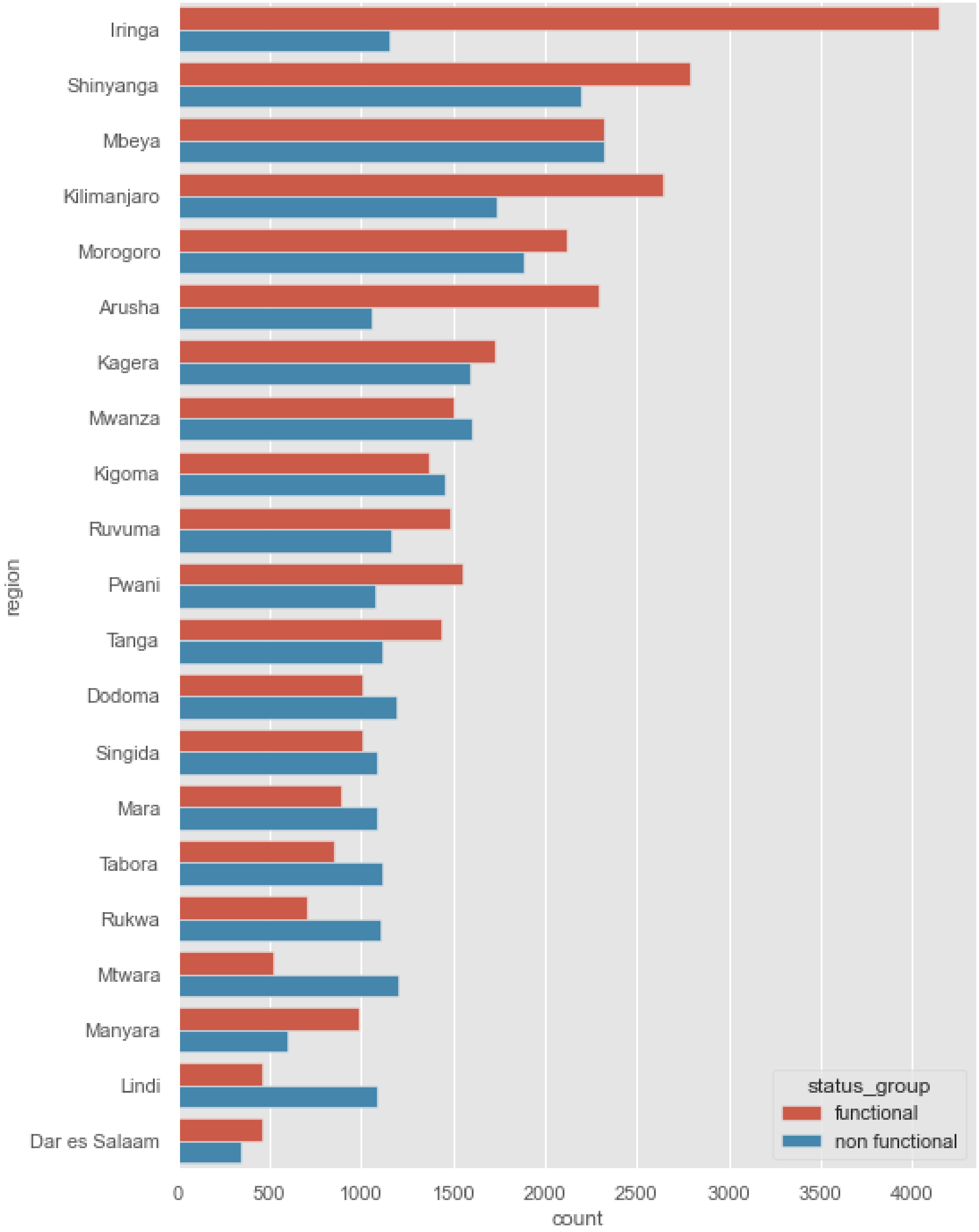
```
       ):
        colors.append('royalblue')
    else:
        colors.append('slategray')

fig, ax = plt.subplots(figsize=(12,8))
ax.barh(grouped_region['region'],grouped_region['population'],color=colors)
ax.set_title('Most populated regions',fontsize=20)
plt.xlabel('Population',fontsize=20)
plt.ylabel('Regions',fontsize=20)
ax.xaxis.set_major_formatter(notation)
plt.style.use('ggplot')
```



[347]:

```
# Creating graph for regions with functionality.
fig, ax = plt.subplots(figsize=(8,12))
ax = sns.countplot(y='region',
                   hue="status_group",
                   data=train_data,order=train_data.region.value_counts().index
                  )
```



Seems to be most functional water points at 'Iringa','Shinyanga' and 'Kilimanjaro' region in order. What about these regions populations ?

**Region_Code**

[274]:
```
train_data.region_code.value_counts()
```

```
[274]: 11    5300
       17    5011
       12    4639
       3     4379
       5     4040
       18    3324
       19    3047
       2     3024
       16    2816
       10    2640
       4     2513
       1     2201
       13    2093
       14    1979
       20    1969
       15    1808
       6     1609
       21    1583
       80    1238
       60    1025
       90     917
       7      805
       99     423
       9      390
       24     326
       8      301
       Name: region_code, dtype: int64
```

```
[275]: train_data['region_code'].replace(40,8,inplace=True)
```

```
[276]: train_data.region_code.value_counts()
```

```
[276]: 11    5300
       17    5011
       12    4639
       3     4379
       5     4040
       18    3324
       19    3047
       2     3024
       16    2816
       10    2640
       4     2513
       1     2201
       13    2093
       14    1979
       20    1969
```

```
15    1808
6     1609
21    1583
80    1238
60    1025
90     917
7      805
99     423
9      390
24     326
8      301
Name: region_code, dtype: int64
```

[277]:
```
train_data.district_code.value_counts()
```

[277]:
```
1     12203
2     11173
3      9998
4      8999
5      4356
6      4074
7      3343
8      1043
30      995
33      874
53      745
43      505
13      391
23      293
63      195
62      109
60       63
0        23
80       12
67        6
Name: district_code, dtype: int64
```

Region code and district code columns almost represent same things. Also they are in multicolienarity with each other. We are going to drop district code column.

**Population**

[278]:
```
train_data.population.value_counts()
```

[278]:
```
0       21381
1        7025
200      1940
150      1892
```

```
250       1681
         …
3241         1
1960         1
1685         1
2248         1
1439         1
Name: population, Length: 1049, dtype: int64
```

```
[279]: #train_data['population'].replace(to_replace = 0 , value =281, inplace=True)␣
        ↪#changing 0's to mean
```

```
[388]: def split_population(p):
           if p < 10:
               return 'Low population at the water source.'
           if 10 < p < 200:
               return 'Under 200 people population.'
           return 'High population.'
```

```
[389]: train_data['population'] = train_data['population'].apply(split_population)
```

```
[390]: train_data.population.value_counts()
```

```
[390]: High population.                        38709
       Under 200 people population.            13545
       Low population at the water source.      7146
       Name: population, dtype: int64
```

### Public_meeting

```
[53]: train_data.public_meeting.value_counts(normalize=True)
```

```
[53]: 1    0.858771
      0    0.141229
      Name: public_meeting, dtype: float64
```

### Scheme_management Column

```
[54]: train_data.scheme_management.value_counts()
```

```
[54]: VWC                   36793
      WUG                    5206
      Missing                3877
      Water authority        3153
      WUA                    2883
      Water Board            2748
      Parastatal             1680
```

```
Private operator     1063
Company              1061
Other                 766
SWC                    97
Trust                  72
None                    1
Name: scheme_management, dtype: int64
```

```
[55]: train_data.loc[train_data['scheme_management']
                     .value_counts()
                     [train_data['scheme_management']]
                     .values < 200, 'scheme_management'] = "Other"
```

```
[56]: train_data.scheme_management.value_counts()
```

```
[56]: VWC                   36793
      WUG                    5206
      Missing                3877
      Water authority        3153
      WUA                    2883
      Water Board            2748
      Parastatal             1680
      Private operator       1063
      Company                1061
      Other                   936
      Name: scheme_management, dtype: int64
```

### Construction_year Column

```
[57]: train_data.construction_year.value_counts(normalize =True)
```

```
[57]: 0       0.348636
      2010    0.044529
      2008    0.043990
      2009    0.042643
      2000    0.035202
      2007    0.026717
      2006    0.024764
      2003    0.021650
      2011    0.021145
      2004    0.018906
      2012    0.018249
      2002    0.018098
      1978    0.017458
      1995    0.017071
      2005    0.017020
      1999    0.016481
      1998    0.016263
```

```
1990    0.016061
1985    0.015909
1980    0.013653
1996    0.013653
1984    0.013114
1982    0.012525
1994    0.012424
1972    0.011919
1974    0.011380
1997    0.010842
1992    0.010774
1993    0.010236
2001    0.009091
1988    0.008771
1983    0.008215
1975    0.007357
1986    0.007306
1976    0.006970
1970    0.006919
1991    0.005455
1989    0.005320
1987    0.005084
1981    0.004007
1977    0.003401
1979    0.003232
1973    0.003098
2013    0.002963
1971    0.002441
1960    0.001717
1967    0.001481
1963    0.001431
1968    0.001296
1969    0.000993
1964    0.000673
1962    0.000505
1961    0.000354
1965    0.000320
1966    0.000286
Name: construction_year, dtype: float64
```

```
[58]: train_data[train_data.construction_year>0]['construction_year'].median()
```

```
[58]: 2000.0
```

```
[59]: # Since construction_year column's median 2000 , We are going to replace␣
       ↪missing value 0's to 2000.
```

```
train_data['construction_year'].replace(to_replace = 0, value = 2000,␣
↪inplace=True)
```

[60]:

```
train_data.construction_year.value_counts()
```

[60]:

```
2000    22800
2010     2645
2008     2613
2009     2533
2007     1587
2006     1471
2003     1286
2011     1256
2004     1123
2012     1084
2002     1075
1978     1037
1995     1014
2005     1011
1999      979
1998      966
1990      954
1985      945
1996      811
1980      811
1984      779
1982      744
1994      738
1972      708
1974      676
1997      644
1992      640
1993      608
2001      540
1988      521
1983      488
1975      437
1986      434
1976      414
1970      411
1991      324
1989      316
1987      302
1981      238
1977      202
1979      192
1973      184
```

```
2013     176
1971     145
1960     102
1967      88
1963      85
1968      77
1969      59
1964      40
1962      30
1961      21
1965      19
1966      17
Name: construction_year, dtype: int64
```

[61]:

```
def split_year(y):
    if y < 1970:
        return '60`s year construction.'
    if y < 1980:
        return '70`s year construction.'
    if y < 1990:
        return '80`s year construction.'
    if y < 2000:
        return '90`s year construction.'
    if y < 2010:
        return '2000`s year construction.'
    if y < 2020:
        return '2010`s year construction.'
```

[62]:

```
train_data['construction_year'] = train_data['construction_year'].
 ↪apply(split_year)
```

[63]:

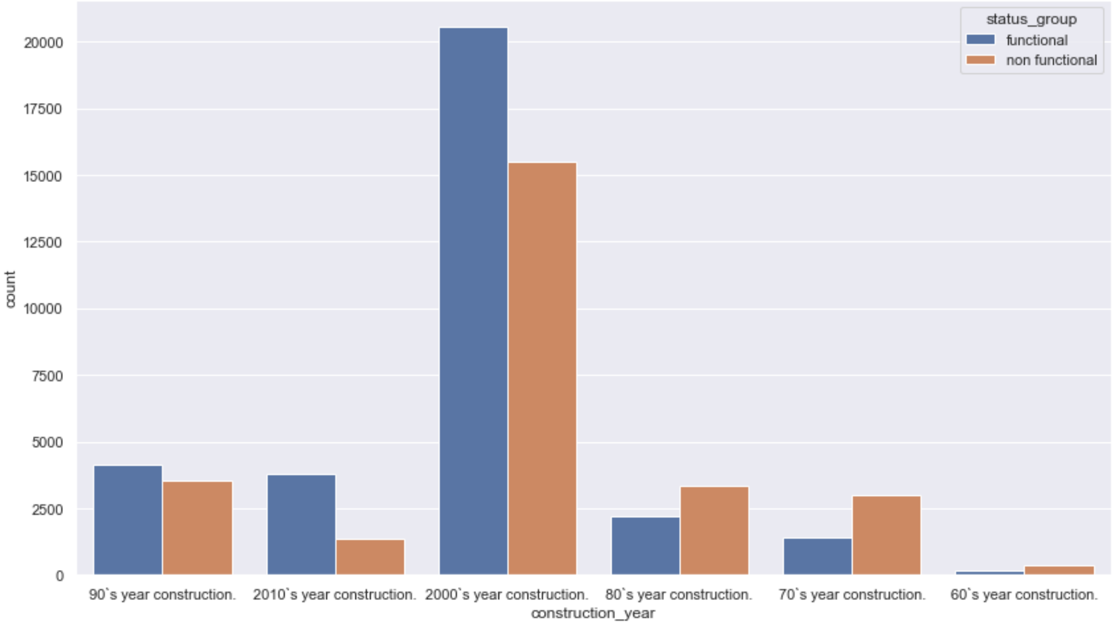
```
train_data['construction_year'].value_counts()
```

[63]:

```
2000`s year construction.    36039
90`s year construction.       7678
80`s year construction.       5578
2010`s year construction.     5161
70`s year construction.       4406
60`s year construction.        538
Name: construction_year, dtype: int64
```

[64]:

```
fig, ax = plt.subplots(figsize=(14,8))
ax = sns.countplot(x='construction_year', hue="status_group", data=train_data )
```



Looks like most of the water points before 90's construction non functional and needs repair.

**Extraction_type Column**

[65]:
```
train_data['extraction_type'].value_counts()
```

[65]:
```
gravity                      26780
nira/tanira                   8154
other                         6430
submersible                   4764
swn 80                        3670
mono                          2865
india mark ii                 2400
afridev                       1770
ksb                           1415
other - rope pump              451
other - swn 81                 229
windmill                       117
india mark iii                  98
cemo                            90
other - play pump               85
walimi                          48
climax                          32
other - mkulima/shinyanga        2
Name: extraction_type, dtype: int64
```

[66]:

```
#Reducing this column's features.
train_data.loc[train_data['extraction_type']
               .value_counts()
               [train_data['extraction_type']]
               .values < 500, 'extraction_type'] = "Other"
```

[67]:

```
train_data['extraction_type'].value_counts()
```

[67]:

```
gravity           26780
nira/tanira        8154
other              6430
submersible        4764
swn 80             3670
mono               2865
india mark ii      2400
afridev            1770
ksb                1415
Other              1152
Name: extraction_type, dtype: int64
```

[68]:

```
train_data['extraction_type_group'].value_counts()
```

[68]:

```
gravity             26780
nira/tanira          8154
other                6430
submersible          6179
swn 80               3670
mono                 2865
india mark ii        2400
afridev              1770
rope pump             451
other handpump        364
other motorpump       122
wind-powered          117
india mark iii         98
Name: extraction_type_group, dtype: int64
```

[69]:

```
train_data['extraction_type_class'].value_counts()
```

[69]:

```
gravity         26780
handpump        16456
other            6430
submersible      6179
motorpump        2987
rope pump         451
wind-powered      117
Name: extraction_type_class, dtype: int64
```

[70]:
```
# Replacing this column's unneceseray values.
train_data['extraction_type_class'].replace('rope pump','other',inplace=True)
train_data['extraction_type_class'].replace('wind-powered','other',inplace=True)
```

### Management Column

[71]:
```
train_data['management'].value_counts()
```

[71]:
```
vwc                 40507
wug                  6515
water board          2933
wua                  2535
private operator     1971
parastatal           1768
water authority       904
other                 844
company               685
unknown               561
other - school         99
trust                  78
Name: management, dtype: int64
```

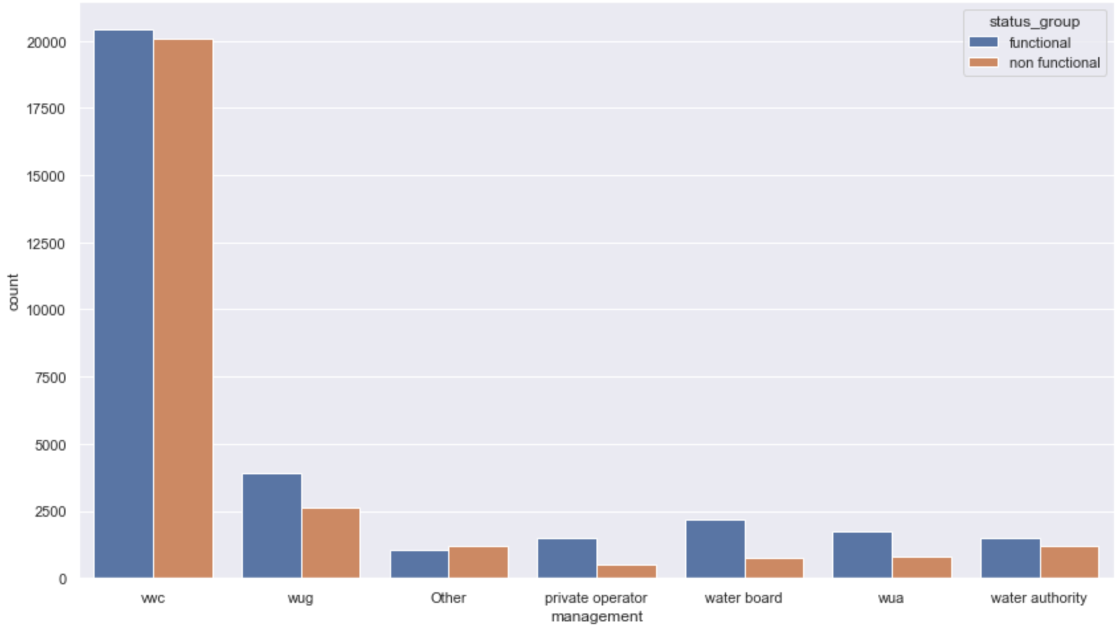
[72]:
```
#Reducing this column's features.
train_data.loc[train_data['management']
               .value_counts()
               [train_data['management']]
               .values < 900, 'management'] = "Other"
```

[73]:
```
train_data['management'].replace('parastatal','water authority',inplace=True)
```

[74]:
```
train_data['management'].value_counts()
```

[74]:
```
vwc                 40507
wug                  6515
water board          2933
water authority      2672
wua                  2535
Other                2267
private operator     1971
Name: management, dtype: int64
```

[75]:
```
# Plotting management with functionality.
fig, ax = plt.subplots(figsize=(14,8))
ax = sns.countplot(x='management', hue="status_group", data=train_data )
```



[76]:
```
train_data['management_group'].value_counts()
```

[76]:
```
user-group    52490
commercial     3638
parastatal     1768
other           943
unknown         561
Name: management_group, dtype: int64
```

[77]:
```
train_data['management_group'].replace('unkown','other',inplace=True)
```

### Payment and Other Columns

[78]:
```
train_data['payment'].value_counts()
```

[78]:
```
never pay                25348
pay per bucket            8985
pay monthly               8300
unknown                   8157
pay when scheme fails     3914
pay annually              3642
other                     1054
Name: payment, dtype: int64
```

[79]:
```
train_data['payment_type'].value_counts()
```

```
[79]: never pay     25348
      per bucket     8985
      monthly        8300
      unknown        8157
      on failure     3914
      annually       3642
      other          1054
      Name: payment_type, dtype: int64
```

```
[80]: train_data['water_quality'].value_counts()
```

```
[80]: soft                  50818
      salty                  4856
      unknown                1876
      milky                   804
      coloured                490
      salty abandoned         339
      fluoride                200
      fluoride abandoned       17
      Name: water_quality, dtype: int64
```

```
[81]: train_data.loc[train_data['water_quality']
                     .value_counts()
                     [train_data['water_quality']]
                     .values < 9000, 'water_quality'] = "Bad"
```

```
[82]: train_data['water_quality'].value_counts()
```

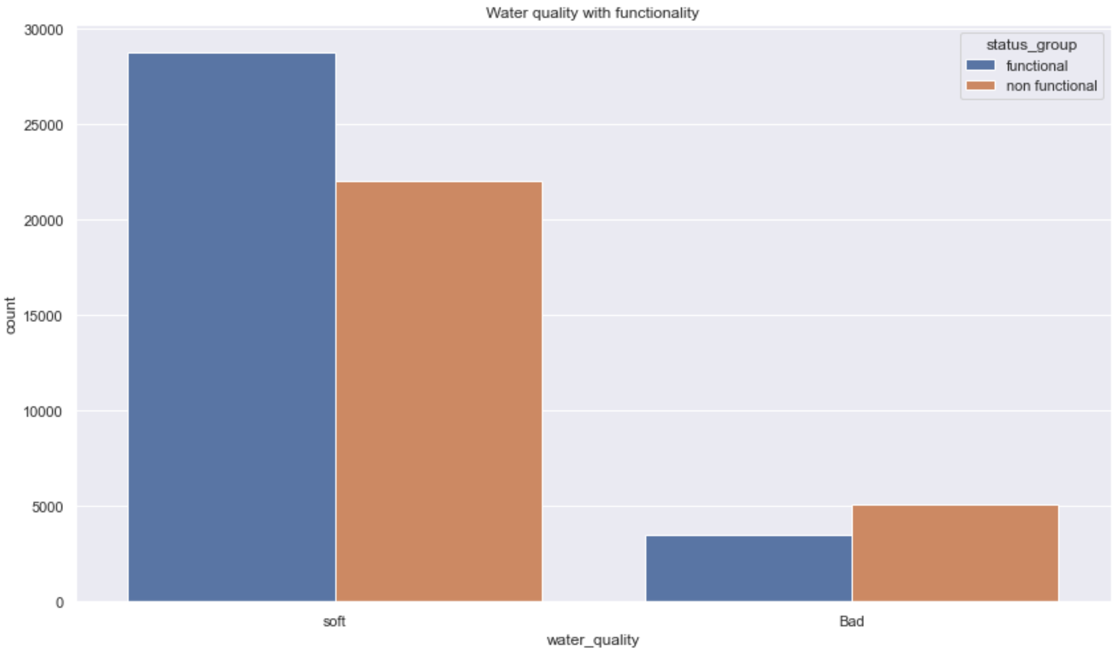
```
[82]: soft    50818
      Bad      8582
      Name: water_quality, dtype: int64
```

```
[83]: train_data['quality_group'].value_counts()
```

```
[83]: good        50818
      salty        5195
      unknown      1876
      milky         804
      colored       490
      fluoride      217
      Name: quality_group, dtype: int64
```

```
[84]: fig, ax = plt.subplots(figsize=(14,8))
      ax = sns.countplot(x='water_quality', hue="status_group", data=train_data )
      ax.set_title('Water quality with functionality')
```

```
[84]: Text(0.5, 1.0, 'Water quality with functionality')
```



### Quantity Column

```
[85]: train_data['quantity'].value_counts()
```

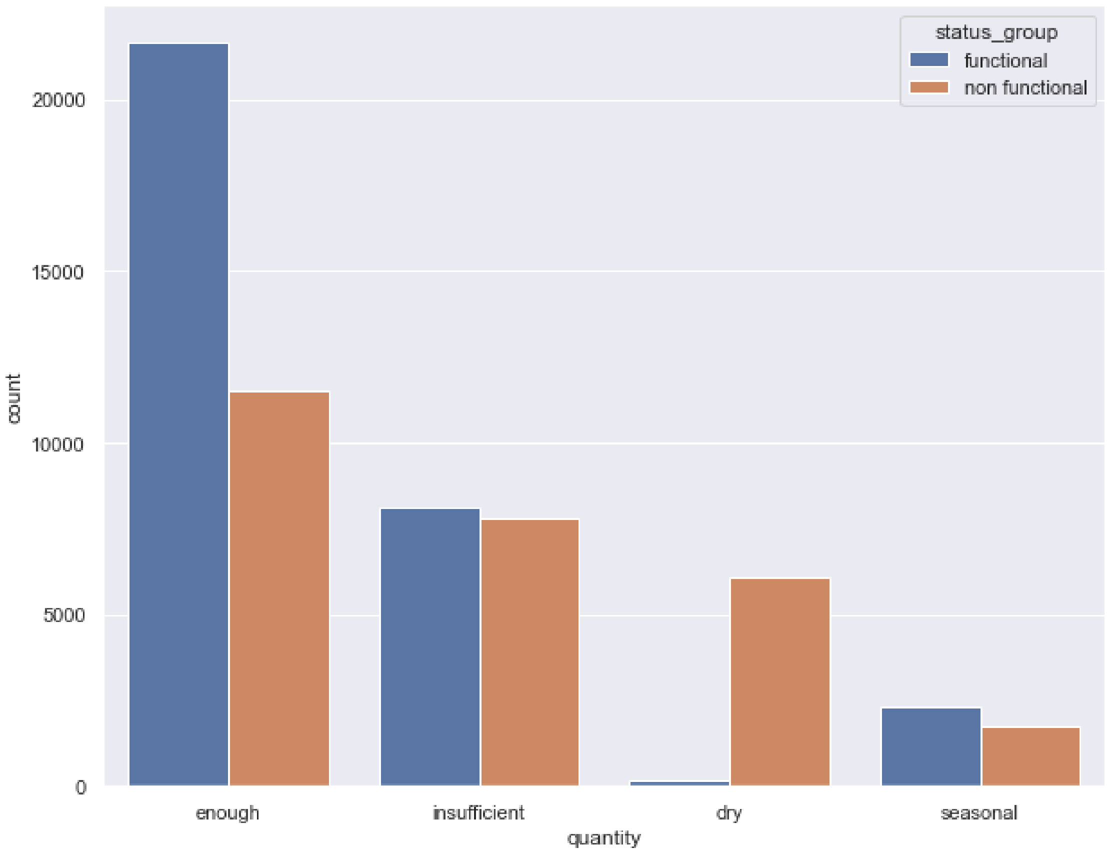
```
[85]: enough          33186
      insufficient    15129
      dry              6246
      seasonal         4050
      unknown           789
      Name: quantity, dtype: int64
```

```
[86]: train_data['quantity'].replace('unknown','insufficient',inplace=True)
```

```
[87]: train_data['quantity'].value_counts()
```

```
[87]: enough          33186
      insufficient    15918
      dry              6246
      seasonal         4050
      Name: quantity, dtype: int64
```

```
[88]: fig, ax = plt.subplots(figsize=(10,8))
      ax = sns.countplot(x='quantity', hue="status_group", data=train_data)
```



It can be seen obviously that although there are enough water quantity in some wells, they are non-functional. When looking at this graph, dry quantity water points have a highly correlation with non-functionality. If the water point is dry , there is high chance the water point is non functional. On the other hand, if the quantity is enough, there is a higher chance to find functional water points.

[89]:
```
train_data['quantity_group'].value_counts()
```

[89]:
```
enough          33186
insufficient    15129
dry              6246
seasonal         4050
unknown           789
Name: quantity_group, dtype: int64
```

[90]:
```
train_data['source'].value_counts()
```

[90]:
```
spring                  17021
shallow well            16824
machine dbh             11075
```

```
river                     9612
rainwater harvesting      2295
hand dtw                   874
lake                       765
dam                        656
other                      212
unknown                     66
Name: source, dtype: int64
```

[91]:

```
train_data.loc[train_data['source']
               .value_counts()
               [train_data['source']]
               .values < 900, 'source'] = "Other"
```

[92]:

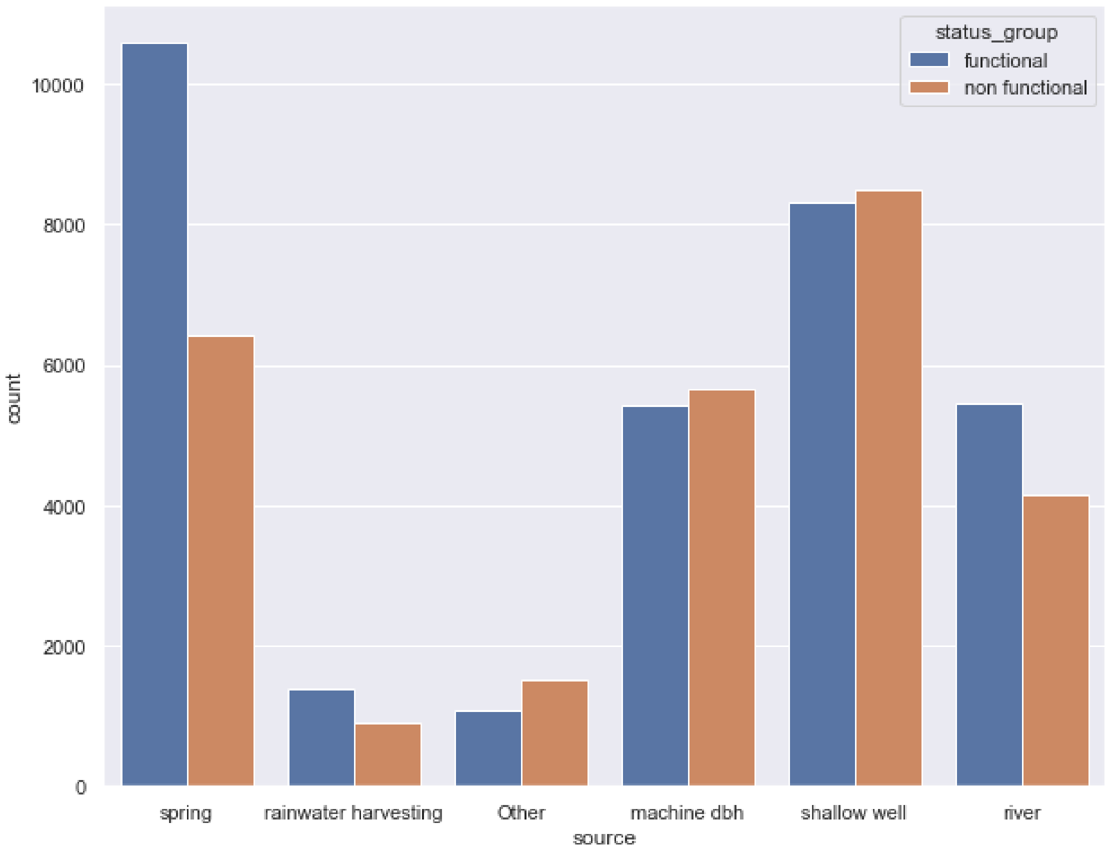
```
train_data['source'].value_counts()
```

[92]:

```
spring                   17021
shallow well             16824
machine dbh              11075
river                     9612
Other                     2573
rainwater harvesting      2295
Name: source, dtype: int64
```

[93]:

```
fig, ax = plt.subplots(figsize=(10,8))
ax = sns.countplot(x='source', hue="status_group", data=train_data)
```



Looks like spring waters most valuable according to this graph. If th water point takes spring water mostly water point will be functional. The other water sources almost evenly functional and non functional depend on other features.

```
[94]: train_data['source_type'].value_counts()
```

```
[94]: spring                  17021
      shallow well            16824
      borehole                11949
      river/lake              10377
      rainwater harvesting     2295
      dam                       656
      other                     278
      Name: source_type, dtype: int64
```

```
[95]: train_data['source_class'].value_counts()
```

```
[95]: groundwater    45794
      surface        13328
      unknown          278
```

```
Name: source_class, dtype: int64
```

[96]:

```
train_data['source_class'].replace('unknown','surface',inplace=True)
```

[377]:

```
train_data['waterpoint_type'].value_counts()
```

[377]:

```
communal standpipe              28522
hand pump                       17488
other                            6380
communal standpipe multiple      6103
improved spring                   784
cattle trough                     116
dam                                 7
Name: waterpoint_type, dtype: int64
```

[378]:

```
train_data.loc[train_data['waterpoint_type']
                .value_counts()
                [train_data['waterpoint_type']]
                .values < 900, 'waterpoint_type'] = "other"
```

[379]:

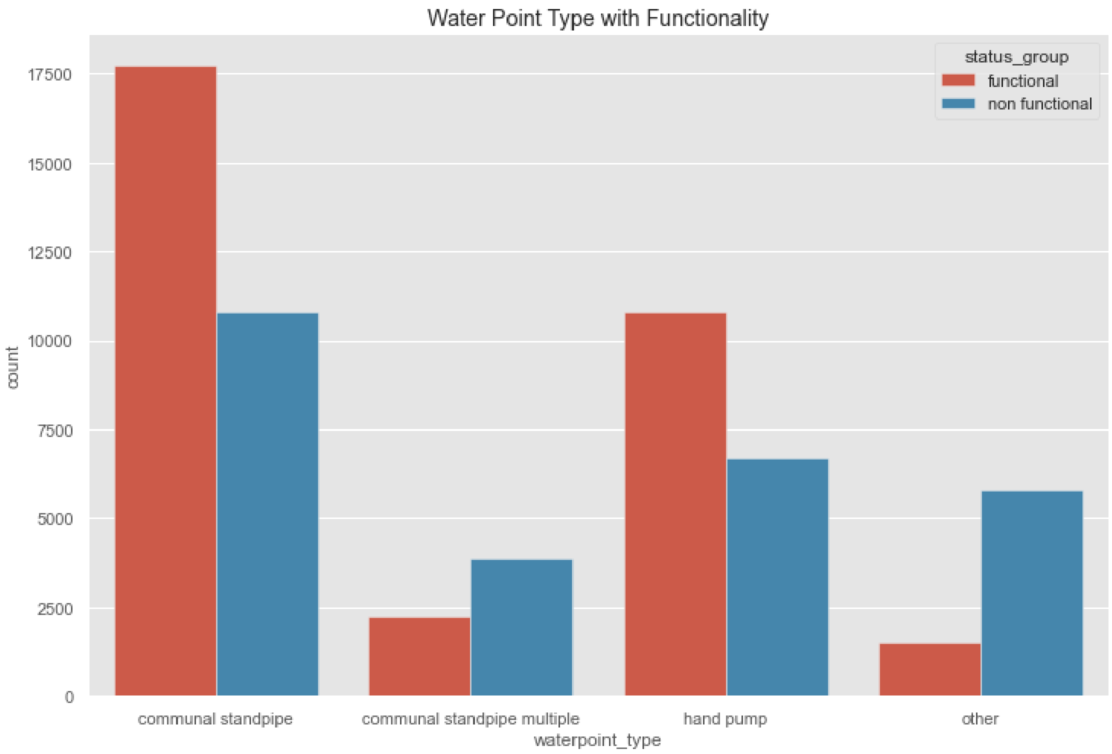
```
train_data['waterpoint_type'].value_counts()
```

[379]:

```
communal standpipe              28522
hand pump                       17488
other                            7287
communal standpipe multiple      6103
Name: waterpoint_type, dtype: int64
```

[385]:

```
fig, ax = plt.subplots(figsize=(12,8))
ax = sns.countplot(x='waterpoint_type', hue="status_group", data=train_data)
ax.set_title('Water Point Type with Functionality')
plt.show()
```



[100]:
```
train_data['waterpoint_type_group'].value_counts()
```

[100]:
```
communal standpipe    34625
hand pump             17488
other                  6380
improved spring         784
cattle trough           116
dam                       7
Name: waterpoint_type_group, dtype: int64
```

[101]:
```
train_data['longitude'].value_counts()
```

[101]:
```
0.000000     1812
37.540901       2
33.010510       2
39.093484       2
32.972719       2
             …
37.579803       1
33.196490       1
34.017119       1
33.788326       1
30.163579       1
```

```
Name: longitude, Length: 57516, dtype: int64
```

```
[102]: train_data['longitude'].replace(0.0,train_data
                                 [train_data['longitude']!= 0]
                                 ['longitude'].mean(),
                                inplace=True)
```

```
[103]: train_data['latitude'].value_counts()
```

```
[103]: -2.000000e-08    1812
       -6.985842e+00       2
       -3.797579e+00       2
       -6.981884e+00       2
       -7.104625e+00       2
                         …
       -5.726001e+00       1
       -9.646831e+00       1
       -8.124530e+00       1
       -2.535985e+00       1
       -2.598965e+00       1
       Name: latitude, Length: 57517, dtype: int64
```

```
[104]: train_data[train_data['permit'] == 1]['status_group'].value_counts()
```

```
[104]: functional        21541
       non functional    17311
       Name: status_group, dtype: int64
```

```
[105]: train_data[train_data['permit'] == 0]['status_group'].value_counts()
```

```
[105]: functional        10718
       non functional     9830
       Name: status_group, dtype: int64
```

```
[106]: # EDA Exploration data analysis
```

```
[107]: le = LabelEncoder()
       train_data['status_group'] = le.fit_transform(train_data['status_group'].values)
```

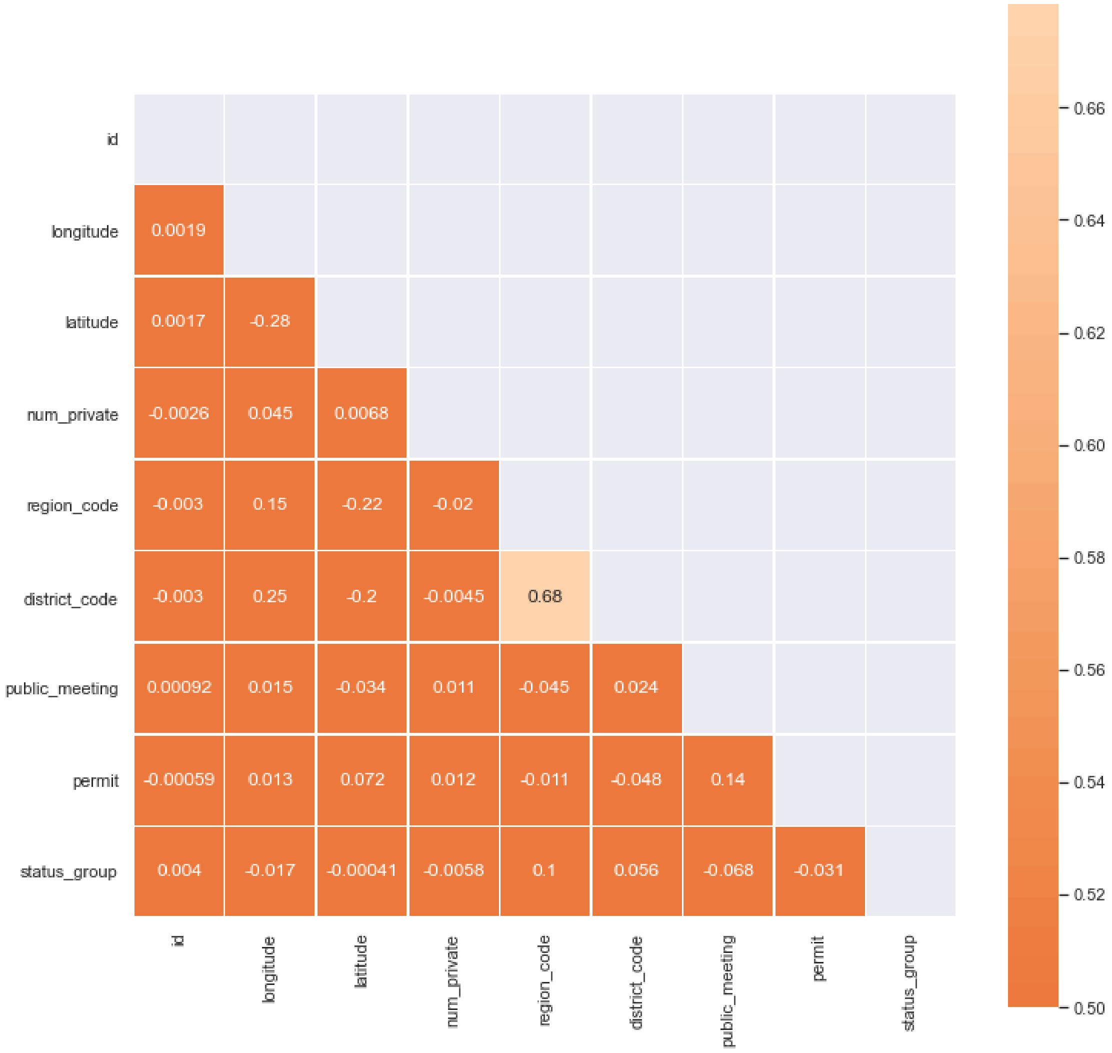
```
[108]: train_data['status_group'].value_counts()
```

```
[108]: 0    32259
       1    27141
       Name: status_group, dtype: int64
```

```
[109]: ## Checking Correlation
       plt.figure(figsize=(12,12))
       corr = train_data.corr()
```

```
mask = np.zeros_like(corr, dtype=np.bool)
mask[np.triu_indices_from(mask)] = True

sns.heatmap(corr, mask=mask ,annot=True, center=0, vmin=.5, square=True,␣
 ↪linewidth=.5)
plt.show()
```



### 0.4.3 Dropping Unnecessary Columns

```
[110]: #Depend on similar values or unncessary values and multicolienarity , going to␣
 ↪drop these columns.
train_data.
 ↪drop(columns=['id','subvillage','payment_type','quantity_group','num_private',
                         ␣
 ↪'source_type','waterpoint_type_group','district_code','recorded_by',
                          ␣
 ↪'scheme_name','extraction_type_group','lga','ward','wpt_name'],inplace=True,axis=1)
```

[111]:

```
#Checking if we missed something.
train_data.isna().sum()
```

[111]:

```
amount_tsh               0
date_recorded            0
funder                   0
gps_height               0
installer                0
longitude                0
latitude                 0
basin                    0
region                   0
region_code              0
population               0
public_meeting           0
scheme_management        0
permit                   0
construction_year        0
extraction_type          0
extraction_type_class    0
management               0
management_group         0
payment                  0
water_quality            0
quality_group            0
quantity                 0
source                   0
source_class             0
waterpoint_type          0
status_group             0
dtype: int64
```

[112]:

```
# Creating function for metric visualizing.
def get_metrics(clf, X, y):
    y_pred = clf.predict(X)

    my_metrics = (
        (accuracy_score, 'accuracy_score'),
        (recall_score, 'recall_score'),
        (precision_score, 'precision_score'),
        (f1_score, 'f1_score')
    )
    for f, name in my_metrics:
        print(name.title())
        print(f(y, y_pred))
        print()

    plot_confusion_matrix(clf, X, y, normalize='true', cmap='Blues')
    plt.grid(False)
    plt.show()
```

[113]:

```
# Importing in-built score modules.
from sklearn.metrics import (
    accuracy_score,
    precision_score,
    recall_score,
    f1_score,
    classification_report,
    plot_confusion_matrix
)
```

[114]:

```
#looking each columns types.
train_data.dtypes
```

[114]:

```
amount_tsh                object
date_recorded             object
funder                    object
gps_height                object
installer                 object
longitude                float64
latitude                 float64
basin                     object
region                    object
region_code                int64
population                object
public_meeting             int64
scheme_management         object
permit                     int64
construction_year         object
extraction_type           object
extraction_type_class     object
management                object
management_group          object
payment                   object
water_quality             object
quality_group             object
quantity                  object
source                    object
```

```
source_class              object
waterpoint_type           object
status_group               int32
dtype: object
```

## 0.5 First Model(LogReg)

[115]:

```
#Create X and y dataframes and train-test split them
y = train_data['status_group']
X = train_data.drop(columns = ['status_group'], axis = 1)
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state = 42)

#Create categorical and continuous feature split
X_train_cat = X_train.select_dtypes('object')
X_train_cont = X_train.select_dtypes(['float64', 'int64'])

#Set up pipeline for scaling continuous variables
continuous_pipeline = Pipeline(steps=[
    ('ss', StandardScaler())
])

#Set up pipeline for encoding categorical variables
categorical_pipeline = Pipeline(steps=[
    ('ohe', OneHotEncoder(handle_unknown='ignore'))
])

#Bind the scaling and encoding process together
transformers = ColumnTransformer(transformers=[
    ('continuous', continuous_pipeline, X_train_cont.columns),
    ('categorical', categorical_pipeline, X_train_cat.columns)
])

#Pipeline for running the model
model1 = Pipeline(steps=[
    ('transformers', transformers),
    ('log', LogisticRegression(class_weight = 'balanced', solver = 'lbfgs',␣
 ↪random_state=42))
])

#Fitting and checking the score
model1.fit(X_train, y_train)
model1.score(X_train, y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

[115]:
```
0.7543883277216611
```

[116]:
```
model1.steps
```

[116]:
```
[('transformers',
  ColumnTransformer(transformers=[('continuous',
                                   Pipeline(steps=[('ss', StandardScaler())]),
                                   Index(['longitude', 'latitude',
'region_code', 'public_meeting', 'permit'], dtype='object')),
                                  ('categorical',
                                   Pipeline(steps=[('ohe',
OneHotEncoder(handle_unknown='ignore'))]),
                                   Index(['amount_tsh', 'date_recorded',
'funder', 'gps_height', 'installer',
          'basin', 'region', 'population', 'scheme_management',
          'construction_year', 'extraction_type', 'extraction_type_class',
          'management', 'management_group', 'payment', 'water_quality',
          'quality_group', 'quantity', 'source', 'source_class',
          'waterpoint_type'],
         dtype='object'))])),
 ('log', LogisticRegression(class_weight='balanced', random_state=42))]
```

[117]:
```
model1[1].coef_.shape
```

[117]:
```
(1, 168)
```

[118]:
```
# First model score on test data.
model1.score(X_test,y_test)
```

[118]:
```
0.7521885521885522
```

[119]:
```
model1
```

[119]:
```
Pipeline(steps=[('transformers',
                 ColumnTransformer(transformers=[('continuous',
                                                  Pipeline(steps=[('ss',
StandardScaler())]),
                                                  Index(['longitude',
'latitude', 'region_code', 'public_meeting', 'permit'], dtype='object')),
                                                 ('categorical',
                                                  Pipeline(steps=[('ohe',
OneHotEncoder(handle_unknown='ignore'))]),
                                                  Index(['amount_tsh',
'date_recorded', 'funder', 'gps_height', 'installer',
       'basin', 'region', 'population', 'scheme_management',
       'construction_year', 'extraction_type', 'extraction_type_class',
       'management', 'management_group', 'payment', 'water_quality',
       'quality_group', 'quantity', 'source', 'source_class',
       'waterpoint_type'],
      dtype='object'))])),
                ('log',
                 LogisticRegression(class_weight='balanced', random_state=42))])
```

[120]:

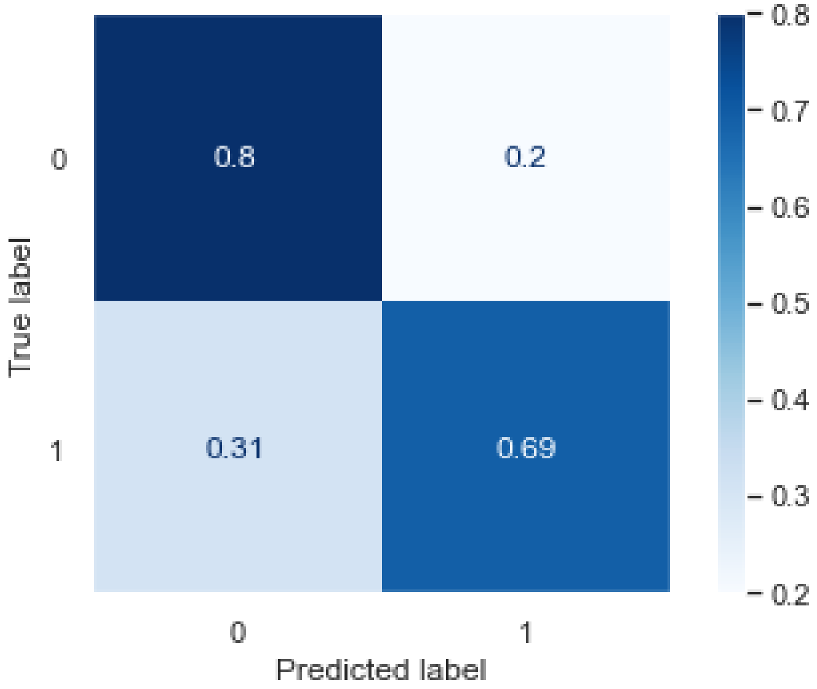
```
# Predicting test data for using on function.
test_pred = model1.predict(X_test)
get_metrics(model1,X_test,y_test)
```

```
Accuracy_Score
0.7521885521885522

Recall_Score
0.6929798578199052

Precision_Score
0.7443525294304805

F1_Score
0.7177481208774353
```



[121]:

```
# Looking metrics.
print(classification_report(y_test,test_pred))
```

```
              precision    recall  f1-score   support

           0       0.76      0.80      0.78      8098
           1       0.74      0.69      0.72      6752

    accuracy                           0.75     14850
   macro avg       0.75      0.75      0.75     14850
weighted avg       0.75      0.75      0.75     14850
```

[122]:

```
# Creating different parameters for gridsearch on forst model(logistic␣
 ↪regression)
ps={
    "log__C":np.logspace(-3,3,7),
    "log__penalty":["l1","l2"]
}
```

[123]:

```
# Grid Search on first model.
grids = GridSearchCV(model1,param_grid=ps,cv=5)
```

[124]:

```python
# Fitting train data.
grids.fit(X_train,y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\pipeline.py", line 335, in fit
    self._final_estimator.fit(Xt, y, **fit_params_last_step)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\pipeline.py", line 335, in fit
    self._final_estimator.fit(Xt, y, **fit_params_last_step)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\pipeline.py", line 335, in fit
    self._final_estimator.fit(Xt, y, **fit_params_last_step)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\pipeline.py", line 335, in fit
    self._final_estimator.fit(Xt, y, **fit_params_last_step)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
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  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py:548: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
set to nan. Details:
Traceback (most recent call last):
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\model_selection\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
```

```
packages\sklearn\pipeline.py", line 335, in fit
    self._final_estimator.fit(Xt, y, **fit_params_last_step)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py", line 442, in _check_solver
    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn("Estimator fit failed. The score on this train-test"
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

[124]:

```
GridSearchCV(cv=5,
             estimator=Pipeline(steps=[('transformers',
ColumnTransformer(transformers=[('continuous',
Pipeline(steps=[('ss',
          StandardScaler())]),
Index(['longitude', 'latitude', 'region_code', 'public_meeting', 'permit'],
dtype='object')),
('categorical',
Pipeline(steps=[('ohe',
          OneHotEncoder(handle_unknown='ignore'))]),
Index(['amount_tsh', 'date_recorded…
       'construction_year', 'extraction_type', 'extraction_type_class',
       'management', 'management_group', 'payment', 'water_quality',
       'quality_group', 'quantity', 'source', 'source_class',
       'waterpoint_type'],
      dtype='object'))])),
                                                ('log',
LogisticRegression(class_weight='balanced',
                                                          random_state=42))]),
             param_grid={'log__C': array([1.e-03, 1.e-02, 1.e-01, 1.e+00,
1.e+01, 1.e+02, 1.e+03]),
                         'log__penalty': ['l1', 'l2']})
```

[125]:

```
grids.score(X_train,y_train)
```

[125]:

```
0.7546576879910213
```

[126]:

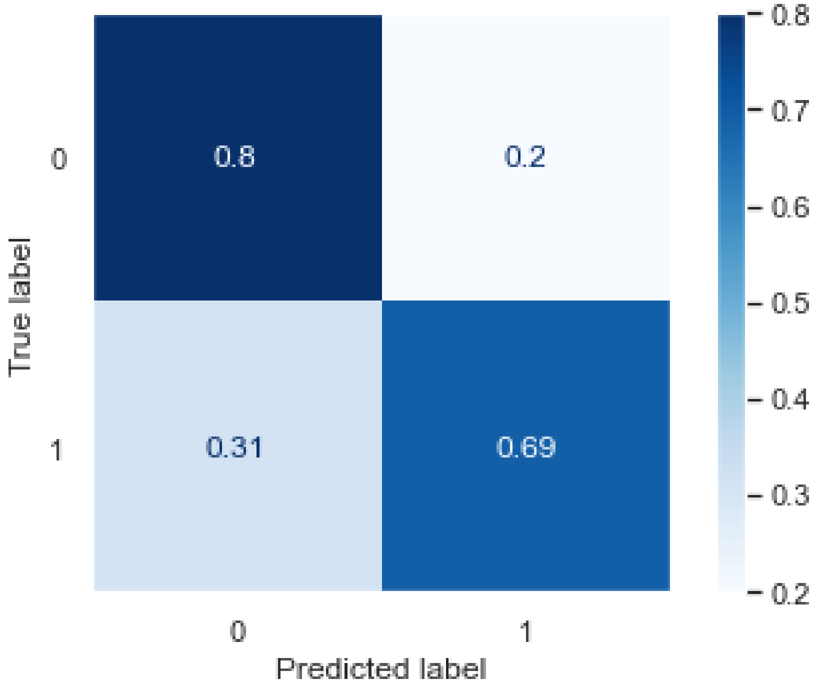
```
# Looking grid search test results for first model.
get_metrics(model1,X_test,y_test)
```

```
Accuracy_Score
0.7521885521885522

Recall_Score
0.6929798578199052

Precision_Score
0.7443525294304805

F1_Score
0.7177481208774353
```



**Our first model Logistic Regression didn't give the best value with Grid Search, We are going to forward with other models.**

## 0.6 Second Model(KNN)

[127]:

```
# Creating second model pipeline with KNeighbors Classifier.
model2= Pipeline(steps=[
    ('transformers', transformers),
    ('knn', KNeighborsClassifier(n_neighbors=3))
])

#Fitting and checking the score
model2.fit(X_train, y_train)
model2.score(X_train, y_train)
```

[127]:

```
0.8902805836139169
```

[128]:

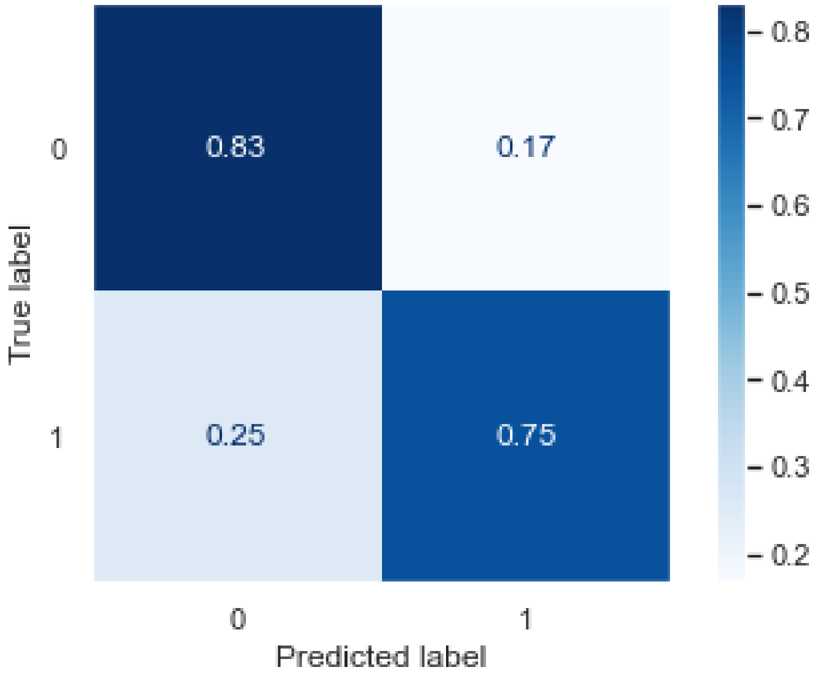
```
# Looking test results for second model.
get_metrics(model2,X_test,y_test)
```

```
Accuracy_Score
0.7938720538720538

Recall_Score
0.7473341232227488

Precision_Score
0.7883143258865802

F1_Score
0.7672774272029196
```



```
[129]: # Creating different parameters for gridsearch on second model(KNeighbors␣
        ↪Classifier)
       prams = {
           'knn__n_neighbors': [3,5,11,19],
           'knn__weights': ['uniform','distance'],
           'knn__metric':['euclidean','manhattan']
       }
```

```
[130]: # Grid Search initializing for second model.
       gr = GridSearchCV(model2,param_grid=prams,cv=3)
```

```
[131]: gr.fit(X_train,y_train)
```

```
[131]: GridSearchCV(cv=3,
                    estimator=Pipeline(steps=[('transformers',
       ColumnTransformer(transformers=[('continuous',
       Pipeline(steps=[('ss',
                  StandardScaler())]),
       Index(['longitude', 'latitude', 'region_code', 'public_meeting', 'permit'],
       dtype='object')),
       ('categorical',
       Pipeline(steps=[('ohe',
                  OneHotEncoder(handle_unknown='ignore'))]),
       Index(['amount_tsh', 'date_recorded…
              'construction_year', 'extraction_type', 'extraction_type_class',
              'management', 'management_group', 'payment', 'water_quality',
              'quality_group', 'quantity', 'source', 'source_class',
              'waterpoint_type'],
             dtype='object'))])),
                                              ('knn',
                                               KNeighborsClassifier(n_neighbors=3))]),
                    param_grid={'knn__metric': ['euclidean', 'manhattan'],
                                'knn__n_neighbors': [3, 5, 11, 19],
                                'knn__weights': ['uniform', 'distance']})
```

[132]:
```
# Grid Search train result.
gr.score(X_train,y_train)
```

[132]:
```
0.997665544332211
```

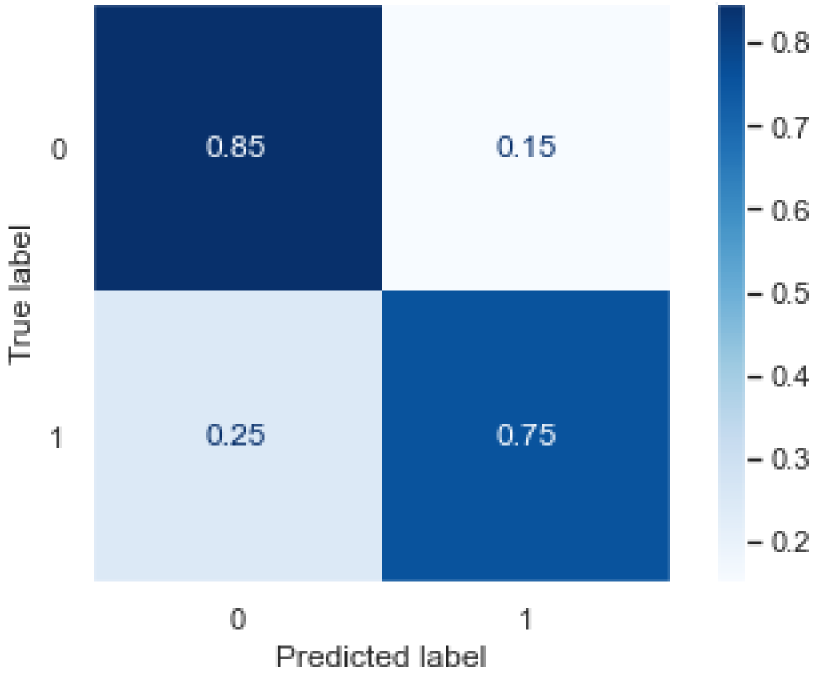
[133]:
```
# Grid Search test results.
get_metrics(gr,X_test,y_test)
```

```
Accuracy_Score
0.806060606060606

Recall_Score
0.754739336492891

Precision_Score
0.8063291139240506

F1_Score
0.7796817625458997
```



## 0.7 Third Model(DecisionTree)

[134]:
```
# Creating third model pipeline with Decision Tree.
model3= Pipeline(steps=[
    ('transformers', transformers),
    ('tree', DecisionTreeClassifier(criterion='gini',max_depth=5))
])

#Fitting and checking the score
model3.fit(X_train, y_train)
model3.score(X_train, y_train)
```

[134]:
```
0.7216835016835017
```

[135]:
```
model3
```

[135]:
```
Pipeline(steps=[('transformers',
                 ColumnTransformer(transformers=[('continuous',
                                                  Pipeline(steps=[('ss',
StandardScaler())]),
                                                  Index(['longitude',
'latitude', 'region_code', 'public_meeting', 'permit'], dtype='object')),
                                                 ('categorical',
                                                  Pipeline(steps=[('ohe',
OneHotEncoder(handle_unknown='ignore'))]),
                                                 Index(['amount_tsh',
'date_recorded', 'funder', 'gps_height', 'installer',
       'basin', 'region', 'population', 'scheme_management',
       'construction_year', 'extraction_type', 'extraction_type_class',
       'management', 'management_group', 'payment', 'water_quality',
       'quality_group', 'quantity', 'source', 'source_class',
       'waterpoint_type'],
      dtype='object'))])),
                ('tree', DecisionTreeClassifier(max_depth=5))])
```

[136]:

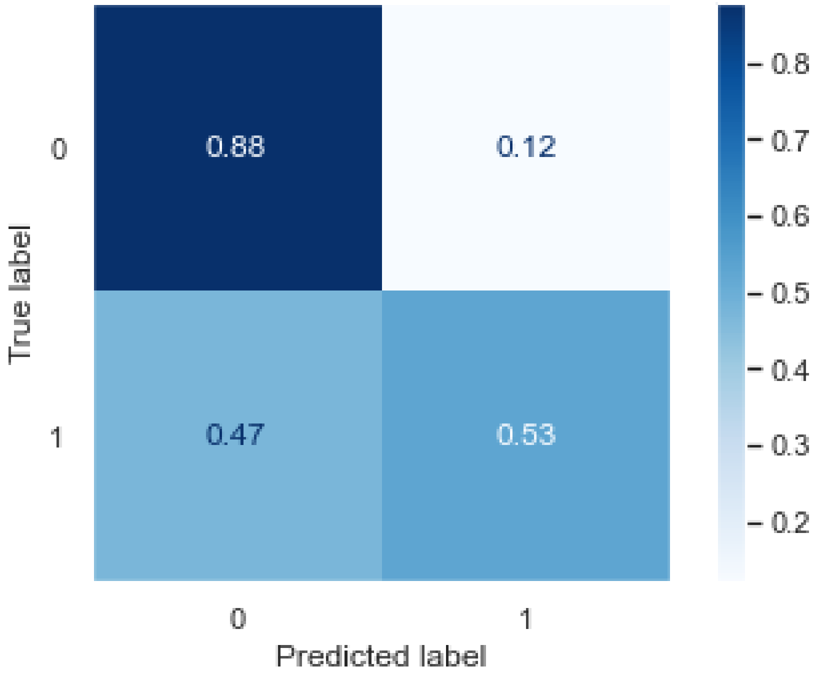
```
# Looking for metric result for test data.
get_metrics(model3,X_test,y_test)
```

```
Accuracy_Score
0.7188552188552189

Recall_Score
0.5266587677725119

Precision_Score
0.7841234840132304

F1_Score
0.6301054310268451
```



[137]:
```
model3.named_steps
```

[137]:
```
{'transformers': ColumnTransformer(transformers=[('continuous',
                                  Pipeline(steps=[('ss', StandardScaler())]),
                                  Index(['longitude', 'latitude', 'region_code',
'public_meeting', 'permit'], dtype='object')),
                                 ('categorical',
                                  Pipeline(steps=[('ohe',
OneHotEncoder(handle_unknown='ignore'))]),
                                  Index(['amount_tsh', 'date_recorded',
'funder', 'gps_height', 'installer',
        'basin', 'region', 'population', 'scheme_management',
        'construction_year', 'extraction_type', 'extraction_type_class',
        'management', 'management_group', 'payment', 'water_quality',
        'quality_group', 'quantity', 'source', 'source_class',
        'waterpoint_type'],
       dtype='object'))]),
 'tree': DecisionTreeClassifier(max_depth=5)}
```

[138]:
```
# Creating different parameters for gridsearch on third model(Decision Tree)
param = {
    'tree__criterion': ['gini', 'entropy'],
    'tree__max_depth': [1,3,5,None],
    'tree__max_features': ['sqrt', 'log2', None],
}
# njobs = -2
```

[139]:
```
# Grid Search initializing for third model.
gr = GridSearchCV(model3,param_grid=param,scoring='recall')
```

[140]:
```
# Fitting and looking train set result.
gr.fit(X_train, y_train)
gr.score(X_train, y_train)
```

[140]:
```
0.9962234538231399
```

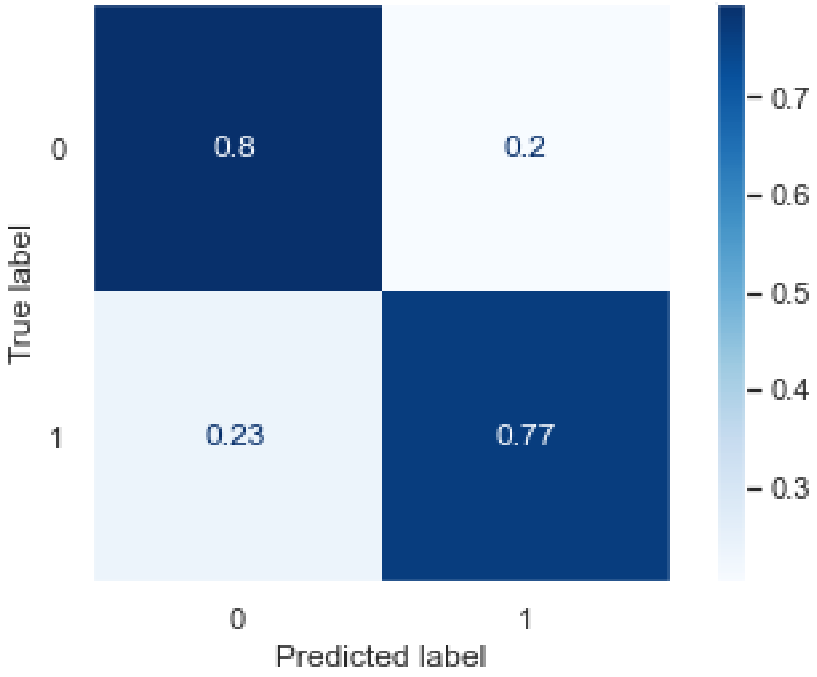
[141]:
```
# Looking test set results.
get_metrics(gr,X_test,y_test)
```

```
Accuracy_Score
0.7833670033670034

Recall_Score
0.7664395734597157

Precision_Score
0.7593543653705063
```

```
F1_Score
0.7628805189061694
```



[142]:

```
gr.best_params_
```

[142]:

```
{'tree__criterion': 'gini',
 'tree__max_depth': None,
 'tree__max_features': None}
```

[143]:

```
gr.best_estimator_
```

[143]:

```
Pipeline(steps=[('transformers',
                 ColumnTransformer(transformers=[('continuous',
                                                  Pipeline(steps=[('ss',
StandardScaler())]),
                                                  Index(['longitude',
'latitude', 'region_code', 'public_meeting', 'permit'], dtype='object')),
                                                 ('categorical',
                                                  Pipeline(steps=[('ohe',
OneHotEncoder(handle_unknown='ignore'))]),
                                                  Index(['amount_tsh',
'date_recorded', 'funder', 'gps_height', 'installer',
       'basin', 'region', 'population', 'scheme_management',
       'construction_year', 'extraction_type', 'extraction_type_class',
       'management', 'management_group', 'payment', 'water_quality',
       'quality_group', 'quantity', 'source', 'source_class',
       'waterpoint_type'],
      dtype='object'))])),
                ('tree', DecisionTreeClassifier())])
```

## 0.8 Fourth (Ensemble) Model

[144]:
```
from sklearn.svm import SVC
from sklearn.ensemble import BaggingClassifier
```

[145]:
```
# Creating fourth model pipeline with ensemble model.
model4= Pipeline(steps=[
    ('transformers', transformers),
    ('bag', BaggingClassifier(XGBClassifier(),
                              n_estimators=10, random_state=0))
])

#Fitting and checking the score
model4.fit(X_train, y_train)
model4.score(X_train, y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:28:24] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:25] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:27] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:28] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:30] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
```

```
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:31] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:32] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:34] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:35] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
[09:28:37] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

[145]:

```
0.8503254769921437
```

[146]:

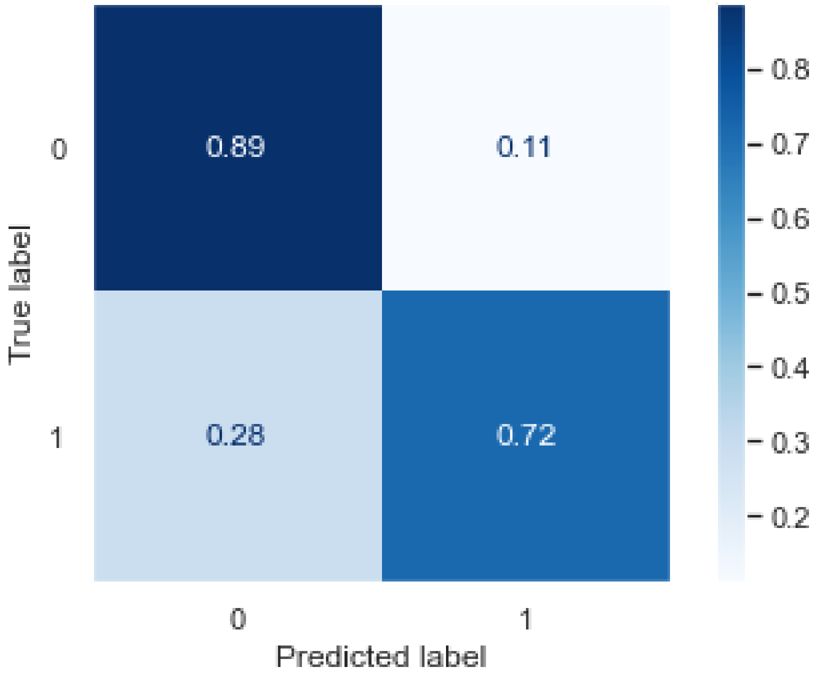
```
#Looking test set result.
get_metrics(model4,X_test,y_test)
```

```
Accuracy_Score
0.8117171717171717

Recall_Score
0.7181575829383886

Precision_Score
0.8444792755137582

F1_Score
0.7762125820393788
```



### 0.9 Random Forest

[147]:
```
# Creating Random Forest model with pipeline.
model5= Pipeline(steps=[
    ('transformers', transformers),
    ('rf', RandomForestClassifier(random_state=42))
])

#Fitting and checking the score
model5.fit(X_train, y_train)
model5.score(X_train, y_train)
```

[147]:
```
0.9975533108866442
```

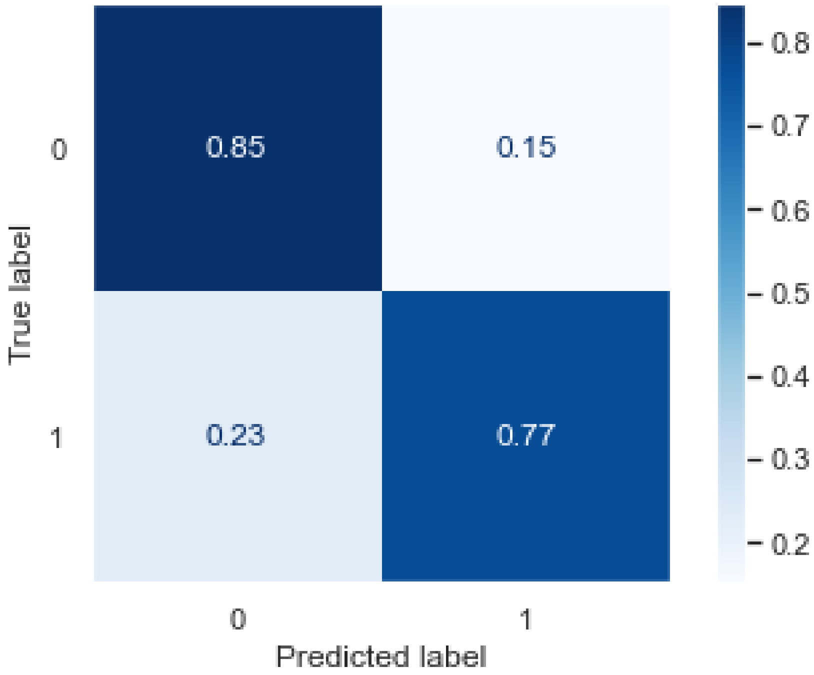
[148]:
```
#Looking test set result.
get_metrics(model5,X_test,y_test)
```

```
Accuracy_Score
0.813063973063973

Recall_Score
0.7711789099526066

Precision_Score
0.8087915501708605
```

```
F1_Score
0.7895375284306292
```



[149]:
```
# Looking cross validation for random forest.
cross_val_score(model5,X_train,y_train)
```

[149]:
```
array([0.81661055, 0.81234568, 0.81133558, 0.81661055, 0.80606061])
```

[150]:
```
# Creating different paramaters for random forest grid search.
param_grid = {
    'rf__n_estimators': [2,5,10,20,50,75,150],
    'rf__max_features': ['auto', 'sqrt', 'log2'],
    'rf__max_depth' : [2,5,10,20,50,None],
    'rf__criterion' :['gini', 'entropy'],
    'rf__min_samples_split':[2,5,10,20]
}
```

[151]:
```
# CV_rfc = GridSearchCV(estimator=model5, param_grid=param_grid, cv= 5)
# CV_rfc.fit(X_train, y_train)
```

[152]:
```
# CV_rfc.score(X_train,y_train)
```

[153]:
```
#get_metrics(CV_rfc,X_test,y_test)
```

[154]:

```
# Predicting test set on random forest model.
test_pred = model5.predict(X_test)
```

[155]:

```
# Looking metrics.
print(classification_report(y_test,test_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.85      0.83      8098
           1       0.81      0.77      0.79      6752

    accuracy                           0.81     14850
   macro avg       0.81      0.81      0.81     14850
weighted avg       0.81      0.81      0.81     14850
```

## 0.10 Voting Classifier

[156]:

```
from sklearn.ensemble import RandomForestClassifier, VotingClassifier
```

[157]:

```
# Initializing another ensemble model.
eclf = VotingClassifier(estimators=[('1', model1), ('2', model2),('3', model3)])
```

[158]:

```
#Fitting train data.
eclf.fit(X_train,y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-
packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

[158]:

```
VotingClassifier(estimators=[('1',
                              Pipeline(steps=[('transformers',
ColumnTransformer(transformers=[('continuous',
Pipeline(steps=[('ss',
                 StandardScaler())]),
Index(['longitude', 'latitude', 'region_code', 'public_meeting', 'permit'],
dtype='object')),
('categorical',
Pipeline(steps=[('ohe',
                 OneHotEncoder(handle_unknown='ignore'))]),
Index(['amount_tsh', 'date_re…
Index(['amount_tsh', 'date_recorded', 'funder', 'gps_height', 'installer',
       'basin', 'region', 'population', 'scheme_management',
       'construction_year', 'extraction_type', 'extraction_type_class',
       'management', 'management_group', 'payment', 'water_quality',
       'quality_group', 'quantity', 'source', 'source_class',
       'waterpoint_type'],
      dtype='object'))])),
                                                ('tree',
DecisionTreeClassifier(max_depth=5))]))])
```

```
[159]: #Checking train set score.
       eclf.score(X_train,y_train)
```

```
[159]: 0.8051178451178451
```

```
[160]: #Checking test set score.
       eclf.score(X_test,y_test)
```

```
[160]: 0.7764309764309765
```

```
[161]: # Predicting test set on Voting Classifier.
       preds= eclf.predict(X_test)
```

```
[162]: # Looking metrics.
       print(classification_report(y_test,preds))
```

```
              precision    recall  f1-score   support

           0       0.75      0.88      0.81      8098
           1       0.82      0.66      0.73      6752

    accuracy                           0.78     14850
   macro avg       0.78      0.77      0.77     14850
weighted avg       0.78      0.78      0.77     14850
```

### 0.11 XGBBoosting with Grid Search

```
[163]: from xgboost import XGBClassifier
```

```
[164]: # Initializing XGB Boosting model.
       model6 = Pipeline(steps=[
           ('transformers', transformers),
           ('xg', XGBClassifier(random_state=42))
       ])

       #Fitting and checking the score
```

```
model6.fit(X_train, y_train)
model6.score(X_train, y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[09:34:43] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

[164]:
```
0.8499438832772166
```

[165]:
```
# Checking test set result.
model6.score(X_test,y_test)
```

[165]:
```
0.8057912457912458
```

[166]:
```
# Different paramaters for xgb boosting.
param_grid = {
    'xg__learning_rate': [0.1, 0.2],
    'xg__max_depth': [6],
    'xg__min_child_weight': [1, 2],
    'xg__subsample': [0.5, 0.7],
    'xg__n_estimators': [100],
}
```

[167]:
```
#Initializing gridsearch and fitting train data.
grid = GridSearchCV(model6,param_grid=param_grid,scoring='recall')
grid.fit(X_train,y_train)
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[09:34:44] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
```

```
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:46] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:47] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:48] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:49] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:51] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:52] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:53] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:55] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:56] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:57] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:34:59] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:00] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:01] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:02] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:04] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:05] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:06] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:08] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:09] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:10] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:12] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:13] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:14] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:15] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:17] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:18] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:19] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:21] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:22] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:23] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:25] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:26] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:27] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:28] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:29] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:31] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

```
C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:32] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:34] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:35] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.

C:\Users\AI\anaconda3\envs\learn-env\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated and will be
removed in a future release. To remove this warning, do the following: 1) Pass
option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, …,
[num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[09:35:36] WARNING: ..\src\learner.cc:1115: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

[167]:
```
GridSearchCV(estimator=Pipeline(steps=[('transformers',
ColumnTransformer(transformers=[('continuous',
Pipeline(steps=[('ss',
          StandardScaler())]),
Index(['longitude', 'latitude', 'region_code', 'public_meeting', 'permit'],
dtype='object')),
('categorical',
Pipeline(steps=[('ohe',
          OneHotEncoder(handle_unknown='ignore'))]),
Index(['amount_tsh', 'date_recorded', 'fu…
                                                      n_estimators=100,
                                                      n_jobs=16,
                                                      num_parallel_tree=1,
                                                      predictor='auto',
                                                      random_state=42,
                                                      reg_alpha=0, reg_lambda=1,
                                                      scale_pos_weight=1,
                                                      subsample=1,
                                                      tree_method='exact',
                                                      validate_parameters=1,
                                                      verbosity=None))]),
             param_grid={'xg__learning_rate': [0.1, 0.2], 'xg__max_depth': [6],
                         'xg__min_child_weight': [1, 2],
                         'xg__n_estimators': [100],
                         'xg__subsample': [0.5, 0.7]},
             scoring='recall')
```

[168]:
```
# Grid Search best parameters.
grid.best_params_
```

[168]:
```
{'xg__learning_rate': 0.2,
 'xg__max_depth': 6,
 'xg__min_child_weight': 1,
 'xg__n_estimators': 100,
 'xg__subsample': 0.5}
```

[169]:
```
# Checking train set result.
grid.score(X_train,y_train)
```

[169]:
```
0.7491294325371524
```

[170]:
```
# Checking test set result.
grid.score(X_test,y_test)
```

[170]:
```
0.7160841232227488
```

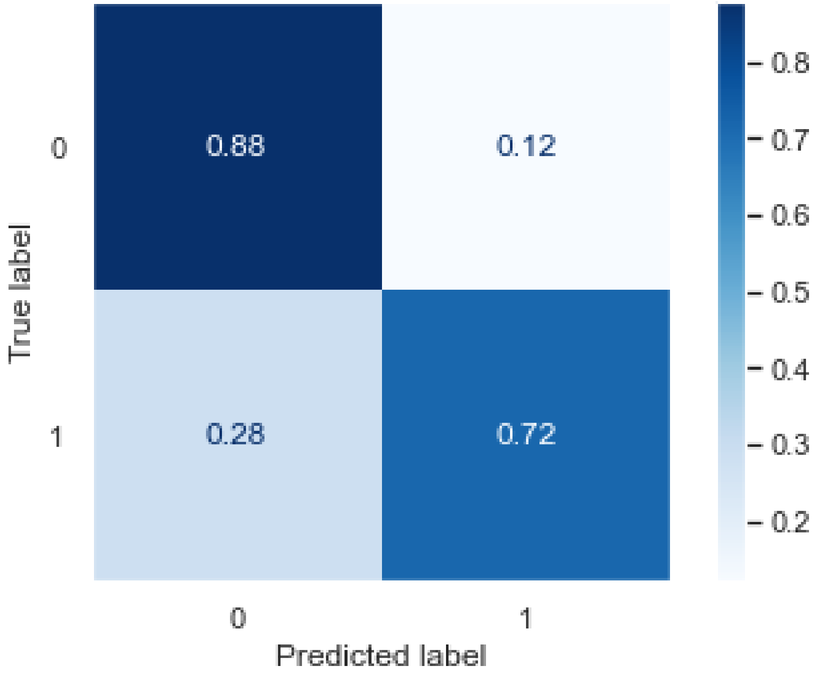
[171]:
```
# Looking metrics.
get_metrics(model6,X_test,y_test)
```

```
Accuracy_Score
0.8057912457912458

Recall_Score
0.7177132701421801

Precision_Score
0.8320741758241759

F1_Score
0.7706743002544529
```



[172]:
```
#Predicting test result.
preds= grid.predict(X_test)
```

[173]:
```
# Checking metrics.
print(classification_report(y_test,preds))
```

```
              precision    recall  f1-score   support

           0       0.79      0.88      0.83      8098
           1       0.83      0.72      0.77      6752

    accuracy                           0.80     14850
```

```
   macro avg       0.81      0.80      0.80     14850
weighted avg       0.81      0.80      0.80     14850
```

## 0.12 Gradient Boosting

[174]:

```
# Initializing Gradient Boosting Classifier with pipeline.
model7 = Pipeline(steps=[
    ('transformers', transformers),
    ('Gbs', GradientBoostingClassifier(random_state=42))
])

#Fitting and checking the score
model7.fit(X_train, y_train)
model7.score(X_train, y_train)
```

[174]:

```
0.770976430976431
```

[175]:

```
# Checking test set result.
model7.score(X_test, y_test)
```

[175]:

```
0.7616161616161616
```

[176]:

```
# Creating different parameters.
params = {
    'Gbs__learning_rate': [0.075, 0.7],
    'Gbs__max_depth': [13, 14],
    'Gbs__min_samples_leaf': [15, 16],
    'Gbs__max_features': [1.0],
    'Gbs__n_estimators': [100, 200]
}
```

[177]:

```
# Initializing grid search and fitting train data.
grid_grad = GridSearchCV(model7, params, cv=5)
grid_grad.fit(X_train, y_train)
```

[177]:

```
GridSearchCV(cv=5,
             estimator=Pipeline(steps=[('transformers',
ColumnTransformer(transformers=[('continuous',
Pipeline(steps=[('ss',
          StandardScaler())]),
Index(['longitude', 'latitude', 'region_code', 'public_meeting', 'permit'],
dtype='object')),
('categorical',
Pipeline(steps=[('ohe',
          OneHotEncoder(handle_unknown='ignore'))]),
Index(['amount_tsh', 'date_recorded…
       'management', 'management_group', 'payment', 'water_quality',
        'quality_group', 'quantity', 'source', 'source_class',
        'waterpoint_type'],
       dtype='object'))])),
                                       ('Gbs',
 GradientBoostingClassifier(random_state=42))]),
             param_grid={'Gbs__learning_rate': [0.075, 0.7],
                         'Gbs__max_depth': [13, 14], 'Gbs__max_features': [1.0],
                         'Gbs__min_samples_leaf': [15, 16],
                         'Gbs__n_estimators': [100, 200]})
```

[193]:
```
grid_grad.best_params_
```

[193]:
```
{'Gbs__learning_rate': 0.075,
 'Gbs__max_depth': 14,
 'Gbs__max_features': 1.0,
 'Gbs__min_samples_leaf': 16,
 'Gbs__n_estimators': 200}
```

[178]:
```
predss = grid_grad.predict(X_test)
```

[179]:
```
#Checking metrics.
print(classification_report(y_test,predss))
```

```
              precision    recall  f1-score   support

           0       0.82      0.88      0.85      8098
           1       0.84      0.76      0.80      6752

    accuracy                           0.83     14850
   macro avg       0.83      0.82      0.82     14850
weighted avg       0.83      0.83      0.82     14850
```

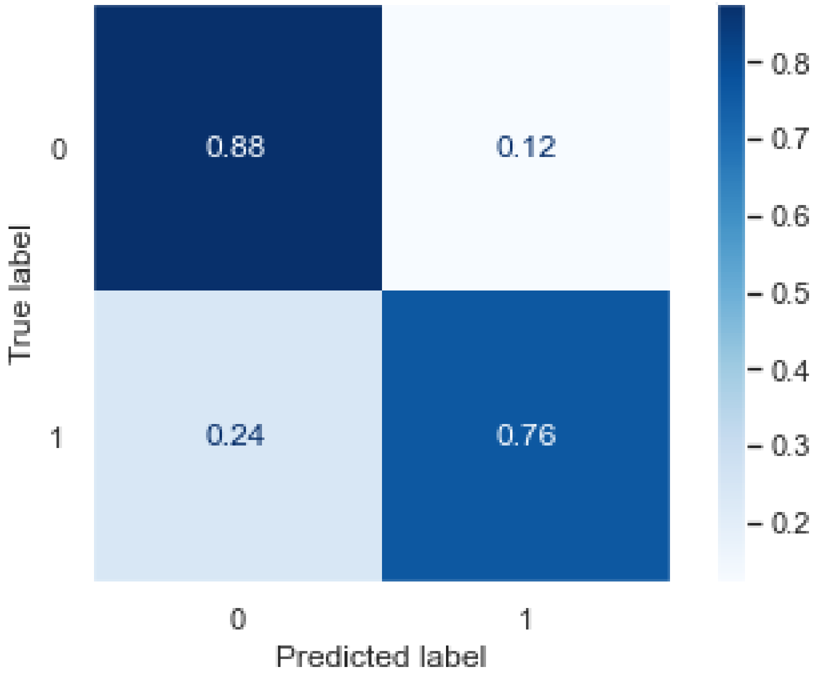
[180]:
```
get_metrics(grid_grad,X_test,y_test)
```

```
Accuracy_Score
0.8251851851851851

Recall_Score
0.7619964454976303

Precision_Score
0.8387675252689925

F1_Score
0.7985410523048269
```



[402]:
```
cross_val_score(grid_grad,X_test,y_test)
```

[402]:
```
array([0.79292929, 0.79427609, 0.79326599, 0.7983165 , 0.78114478])
```

**F-1 score explain how good the quality of predictions are and how completely we've predicted labels from dataset** . My model predicted %79 percent of data correctly according to f-1 score.

### 0.12.1 Out of Pipeline model for visualizing features

[181]:
```
# Seperating numerical and categorical columns.
numerical_cols = X_train.select_dtypes('number').columns.tolist()
categorical_cols = X_train.select_dtypes('object').columns.tolist()
```

[182]:
```
# Create objects. (Only processing X-data.)
imputer = SimpleImputer(missing_values=np.nan)
scaler = StandardScaler()
ohe = OneHotEncoder(handle_unknown='ignore', sparse=False)

# Process data.
X_train_num_processed = imputer.fit_transform(X_train[numerical_cols])
X_test_num_processed = imputer.transform(X_test[numerical_cols])

X_train_num_processed = scaler.fit_transform(X_train_num_processed)
X_test_num_processed = scaler.transform(X_test_num_processed)
```

```
X_train_cat_processed = ohe.fit_transform(X_train[categorical_cols])
X_test_cat_processed = ohe.transform(X_test[categorical_cols])

# Join data back together to look at.
X_train_processed_df = pd.DataFrame(
    np.concatenate([X_train_num_processed, X_train_cat_processed], axis=1),
    columns=numerical_cols + ohe.get_feature_names().tolist())
X_test_processed_df = pd.DataFrame(
    np.concatenate([X_test_num_processed, X_test_cat_processed], axis=1),
    columns=numerical_cols + ohe.get_feature_names().tolist())

# Sanity check.
X_train_processed_df.shape, X_test_processed_df.shape
```

[182]:

```
((44550, 168), (14850, 168))
```

[183]:

```
# Looking first five rows of processed data.
X_train_processed_df.head()
```

[183]:

```
   longitude  latitude  region_code  public_meeting    permit  \
0   1.154510 -0.129019    -0.529291        0.408462  0.729442
1  -0.002107  1.940133     0.092332       -2.448208 -1.370910
2  -0.716629  0.983559     0.205354        0.408462  0.729442
3  -0.144681  0.294199    -0.133713        0.408462  0.729442
4  -0.192166 -1.699526    -0.303246       -2.448208  0.729442

   x0_Enough amount water source at this point.  \
0                                           1.0
1                                           0.0
2                                           0.0
3                                           0.0
4                                           0.0

   x0_Less amount water source at this point.  x1_2011  x1_2012  x1_2013  …  \
0                                         0.0      1.0      0.0      0.0  …
1                                         1.0      0.0      0.0      1.0  …
2                                         1.0      1.0      0.0      0.0  …
3                                         1.0      0.0      0.0      1.0  …
4                                         1.0      0.0      0.0      1.0  …

   x18_rainwater harvesting  x18_river  x18_shallow well  x18_spring  \
0                       0.0        0.0               0.0         0.0
1                       0.0        0.0               1.0         0.0
2                       0.0        0.0               0.0         0.0
3                       1.0        0.0               0.0         0.0
4                       0.0        0.0               0.0         1.0
```

```
   x19_groundwater  x19_surface  x20_communal standpipe  \
0              1.0          0.0                     1.0
1              1.0          0.0                     0.0
2              1.0          0.0                     0.0
3              0.0          1.0                     1.0
4              1.0          0.0                     1.0

   x20_communal standpipe multiple  x20_hand pump  x20_other
0                              0.0            0.0        0.0
1                              0.0            1.0        0.0
2                              0.0            1.0        0.0
3                              0.0            0.0        0.0
4                              0.0            0.0        0.0

[5 rows x 168 columns]
```

[184]:
```
# Initializing Decision Tree model with best parameters we found at before␣
↪model.
t = DecisionTreeClassifier(criterion='entropy',max_features=None,max_depth=None)
```

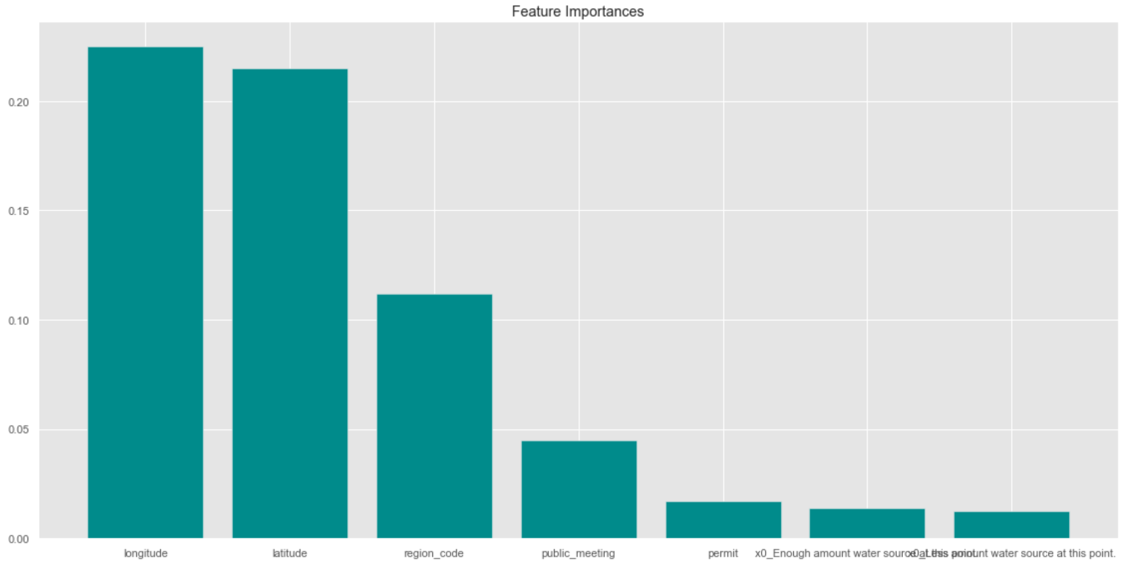
[185]:
```
# Fitting train data.
t.fit(X_train_processed_df,y_train)
```

[185]:
```
DecisionTreeClassifier(criterion='entropy')
```

[186]:
```
# Sorting most important features.
t1 = sorted(t.feature_importances_,reverse=True)
```

[398]:
```
# Plot feature importances.

fig, ax = plt.subplots(figsize=(16,8))
for i,r in zip(t1,X_train_processed_df.columns):
    if i > 0.01:
        ax.bar(r, i, color='darkcyan')
        ax.set(title='Feature Importances')
fig.tight_layout()
```



```
[188]: # Initializing Random Forest.
       r1 = RandomForestClassifier(random_state=42)
```

```
[189]: # Fitting train data.
       r1.fit(X_train_processed_df,y_train)
```

```
[189]: RandomForestClassifier(random_state=42)
```

```
[190]: # Checking random forest most important features.
       r1.feature_importances_
```

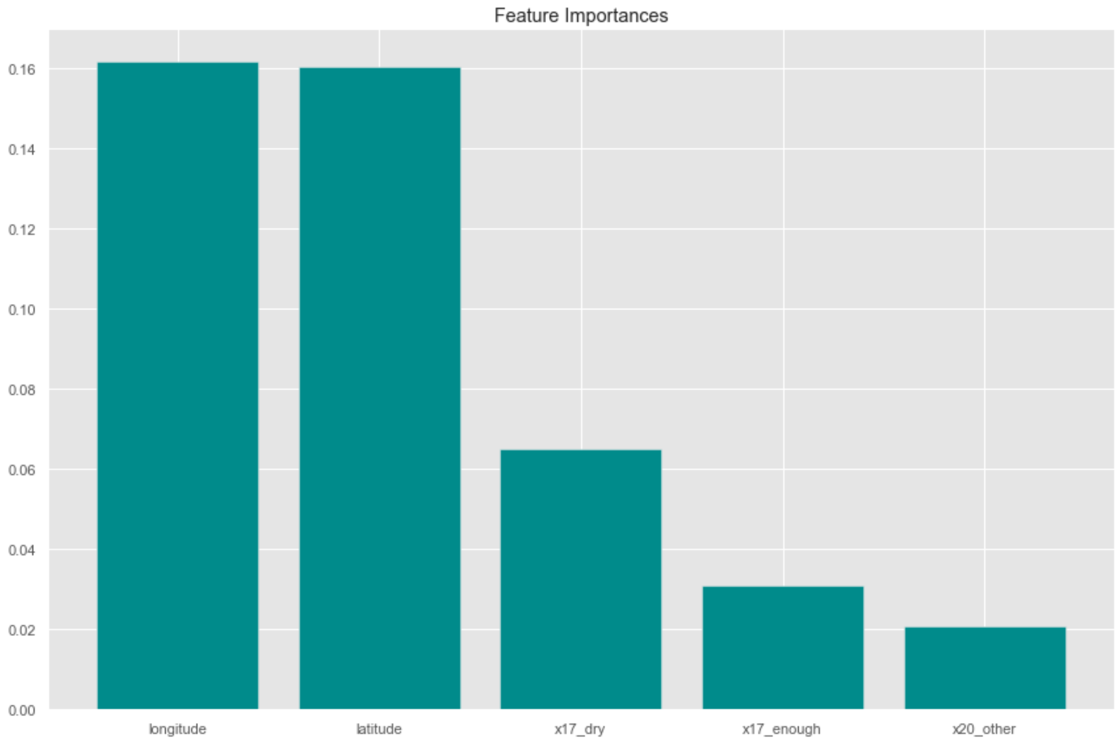
```
[190]: array([1.61540867e-01, 1.60389667e-01, 1.75112330e-02, 8.84434952e-03,
              9.98999268e-03, 1.01304196e-02, 1.04186628e-02, 4.34926765e-03,
              3.23178127e-03, 4.96438123e-03, 6.60745010e-04, 6.45069865e-04,
              4.87285542e-04, 9.76591752e-05, 2.52943635e-03, 2.70560721e-04,
              6.84564597e-04, 1.27543409e-03, 1.12402140e-03, 2.01194671e-03,
              3.53951168e-04, 1.81330567e-04, 2.03103713e-04, 8.87539011e-03,
              2.03475319e-03, 4.57001049e-04, 5.60687036e-04, 4.21751961e-04,
              4.46247904e-04, 8.72472501e-04, 4.43450165e-04, 9.36279344e-04,
              4.36230330e-04, 4.52979787e-04, 8.92361681e-04, 1.06334789e-02,
              5.60516192e-04, 4.77307033e-04, 1.03690415e-03, 1.95262000e-04,
              3.08581959e-04, 1.71045872e-04, 2.79952280e-04, 1.87109992e-04,
              1.58643353e-03, 1.50712306e-04, 2.00894060e-03, 7.96877358e-04,
              1.35530898e-03, 3.34810062e-04, 2.55275220e-03, 6.83559427e-04,
              5.61036532e-04, 2.21554015e-03, 1.52109469e-03, 7.58630083e-04,
              3.78364642e-03, 4.24085501e-03, 9.07284971e-03, 8.46286212e-03,
              8.59049539e-03, 5.04213401e-03, 3.34538282e-03, 2.74786166e-03,
              3.23719518e-03, 2.98825724e-03, 3.09044719e-03, 3.15193760e-03,
              2.28321289e-03, 2.90408846e-03, 2.62123900e-03, 3.55431260e-04,
              1.30893920e-03, 5.99323089e-03, 1.49486820e-03, 2.49925989e-03,
              2.00704939e-03, 1.07287166e-03, 1.23104966e-03, 1.43115422e-03,
              1.41267137e-03, 1.87615531e-03, 1.26627821e-03, 1.94317124e-03,
              1.51139980e-03, 1.22838807e-03, 9.96265059e-04, 1.72518929e-03,
              1.52262086e-03, 9.41154481e-04, 1.57574196e-03, 8.33305881e-03,
              7.53913630e-03, 7.89429431e-03, 1.22651811e-03, 3.05699029e-03,
              1.15043102e-03, 1.16841733e-03, 1.04029727e-03, 6.12731339e-03,
              1.69068073e-03, 2.56484129e-03, 2.32822912e-03, 2.78773440e-03,
              9.29957831e-03, 8.72709239e-03, 1.16400956e-03, 7.94339858e-03,
              5.90639113e-03, 6.33536222e-03, 2.37648114e-03, 2.47327228e-03,
              4.96268258e-03, 2.66441076e-03, 1.84228627e-03, 2.52760180e-03,
              6.14361610e-03, 1.77981404e-02, 2.81462215e-03, 3.58518794e-03,
              4.10281336e-03, 6.04098434e-03, 2.35707146e-03, 1.38022283e-02,
              3.18208296e-03, 2.08192238e-03, 2.14095956e-03, 6.88253164e-03,
              1.74872037e-03, 2.24737839e-03, 1.49458735e-03, 2.98330027e-03,
              2.67045583e-03, 1.00847739e-03, 1.38545097e-03, 6.90219412e-04,
              3.90772584e-03, 1.33228429e-02, 1.22157597e-03, 3.24768303e-03,
              4.86284434e-03, 7.03860312e-03, 3.47527997e-03, 5.52534350e-03,
              4.12326542e-03, 4.02016517e-03, 7.92005770e-04, 4.76629972e-04,
              4.09946731e-03, 1.08534386e-03, 3.26326785e-03, 4.94810098e-03,
              6.49035737e-02, 3.07653746e-02, 1.34818225e-02, 5.97374714e-03,
              3.02912270e-03, 5.04951606e-03, 3.16213180e-03, 3.44944763e-03,
              5.34826047e-03, 6.60568584e-03, 4.78113837e-03, 4.48058073e-03,
              1.25003780e-02, 8.79952043e-03, 7.10986558e-03, 2.08018851e-02])
```

[191]:

```
# Sorting important features.
r11 =  sorted(r1.feature_importances_,reverse=True)
```

[401]:

```
# Plot feature importances.
fig, ax = plt.subplots(figsize=(12,8))
for i,r in zip(r1.feature_importances_,X_train_processed_df.columns):
    if i > 0.018:
        ax.bar(r, i, color='darkcyan')
        ax.set(title='Feature Importances')
fig.tight_layout()
```



## 0.13 Conclusion

In conclusion , built model is predictive of functionality of water wells in Tanzania with a **F-1 Score** 0.79. Validated this score with train test split and cross validation. Final model included 168 variables, most of them one hot encoded columns.

The main metric that I would be using to assess my models' performance here is F-1 Score. F-1 score explain how good the quality of predictions are and how completely we've predicted labels from dataset. We wouldn't look at accuracy score because it would be misleading for our specific project. Because accuracy generally good for balanced classes and if both classes importances the same. We are goin to look at F-1 Score because it is harmonic mean of precision and recall scores what exactly need for this project. Which is for this project 0 Non-Functional class important for us.

## 0.14 Future Work

1. Gather better quality data for prediction model.
2. Bring together old and new data for preparing for modeling.
3. Work on models to predict better.