Milestone 3: Beyond Descriptive Stats (Dive Deeper/Go Broader)

In this milestone, you will go beyond the descriptive statistics you completed in the last milestone. This milestone is really about diving deeper to analyze your data, beyond descriptive stats. Maybe you need to analyze qualitative data or textual data to get a full picture.

Field	Description
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
functional	the waterpoint is operational and there are no repairs needed
non functional	the waterpoint is not operational

Dive Deeper

Look deeper into the features you are investigating, consider:

- Relationships / Correlation, Pearson Correlation
- Linear Regression for future prediction (if the relationship is linear)
- Textual Analysis for TF-IDF (Term Frequency-Inverse Document Frequency; Row-based and column-based, stop-word removal?

Specify 1-2 correlations you discovered. List the fields that you found to be correlated and describe what you learned from these correlations.

The outcomes will be binary, hence correlation done is not useful in this context. Recommend tree-based modeling for classification case.

Go Broader

Expand the features you are investigating. Look for connections/relationships that you may have initially missed.

- What jumps out at you now?
- Use the descriptive stats to point you to features that you may now want to consider.

What key terms did you discover in any text analysis, for whom? Any themes? If you are not analyzing text, summarize what other things you are considering in your analysis?

1. Public Meeting areas has more pumps.
2. Majority of pumps installed have government permits
3. Gravity kind of extraction the pump uses mostly
4. Majority of users never pay for water
5. Main sources are groundwater

New Metric

Create 1 or 2 new metrics to track relationships of data you discovered. Explain why you created them.

Metric is binary outcome.

Import Libraries

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
import datetime

%matplotlib inline
sns.set_style('dark')
sns.set(font_scale=1.2)

import warnings
warnings.filterwarnings('ignore')

import feature_engine.missing_data_imputers as mdi
from feature_engine.outlier_removers import Winsorizer

from sklearn.preprocessing import LabelEncoder, StandardScaler, MinMaxScaler, OneHotEncoder

pd.set_option('display.max_columns',None)
#pd.set_option('display.max_rows',None)
pd.set_option('display.width', 1000)

np.random.seed(0)
np.set_printoptions(suppress=True)
```

In [2]:
```
df = pd.read_csv("train.csv",parse_dates=['date_recorded'])
```

In [3]:
```
df
```

Out[3]:

	id	amount_tsh	date_recorded	funder	gps_height	installer	longitude	latitude	wpt_name	num_private	basin	s
0	69572	6000.0	2011-03-14	Roman	1390	Roman	34.938093	-9.856322	none	0	Lake Nyasa	
1	8776	0.0	2013-06-03	Grumeti	1399	GRUMETI	34.698766	-2.147466	Zahanati	0	Lake Victoria	
2	34310	25.0	2013-02-25	Lottery Club	686	World vision	37.460664	-3.821329	Kwa Mahundi	0	Pangani	
3	67743	0.0	2013-01-28	Unicef	263	UNICEF	38.486161	-11.155298	Zahanati Ya Nanyumbu	0	Ruvuma / Southern Coast	Ma
4	19728	0.0	2011-07-13	Action In A	0	Artisan	31.130847	-1.825359	Shuleni	0	Lake Victoria	K
...	...	...	...	...	...	...	...	...	...	...	...	
59395	60739	10.0	2013-03-05	Germany Republi	1210	CES	37.169807	-3.253847	Area Three Namba 27	0	Pangani	
59396	27263	4700.0	2011-07-05	Cefa-njombe	1212	Cefa	35.249991	-9.070629	Kwa Yahona Kuvala	0	Rufiji	
59397	37057	0.0	2011-11-04	NaN	0	NaN	34.017087	-8.750434	Mashine	0	Rufiji	I
59398	31282	0.0	2011-08-03	Malec	0	Musa	35.861315	-6.378573	Mshoro	0	Rufiji	
59399	26348	0.0	2011-03-23	World Bank	191	World	38.104048	-6.747464	Kwa Mzee Lugawa	0	Wami / Ruvu	Kika

59400 rows × 41 columns

Exploratory Data Analysis

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 59400 entries, 0 to 59399
Data columns (total 41 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  datetime64[ns]
 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  59399 non-null  object
 40  status_group           59399 non-null  object
dtypes: datetime64[ns](1), float64(3), int64(7), object(30)
memory usage: 18.6+ MB
```

In [5]:
```
df.describe()
```

Out[5]:

	id	amount_tsh	gps_height	longitude	latitude	num_private	region_code	district_code	population
count	59400.000000	59400.000000	59400.000000	59400.000000	5.940000e+04	59400.000000	59400.000000	59400.000000	59400.000000
mean	37115.131768	317.650385	668.297239	34.077427	-5.706033e+00	0.474141	15.297003	5.629747	179.909983
std	21453.128371	2997.574558	693.116350	6.567432	2.946019e+00	12.236230	17.587406	9.633649	471.482176
min	0.000000	0.000000	-90.000000	0.000000	-1.164944e+01	0.000000	1.000000	0.000000	0.000000
25%	18519.750000	0.000000	0.000000	33.090347	-8.540621e+00	0.000000	5.000000	2.000000	0.000000
50%	37061.500000	0.000000	369.000000	34.908743	-5.021597e+00	0.000000	12.000000	3.000000	25.000000
75%	55656.500000	20.000000	1319.250000	37.178387	-3.326156e+00	0.000000	17.000000	5.000000	215.000000
max	74247.000000	350000.000000	2770.000000	40.345193	-2.000000e-08	1776.000000	99.000000	80.000000	30500.000000

In [6]:
```
df.columns
```

Out[6]:
```
Index(['id', 'amount_tsh', 'date_recorded', 'funder', 'gps_height', 'installer', 'longitude', 'latitu
de', 'wpt_name', 'num_private', 'basin', 'subvillage', 'region', 'region_code', 'district_code', 'lg
a', 'ward', 'population', 'public_meeting', 'recorded_by', 'scheme_management', 'scheme_name', 'permi
t', 'construction_year', 'extraction_type', 'extraction_type_group', 'extraction_type_class', 'manage
ment', 'management_group', 'payment', 'payment_type', 'water_quality', 'quality_group', 'quantity',
'quantity_group', 'source', 'source_type', 'source_class', 'waterpoint_type', 'waterpoint_type_grou
p', 'status_group'], dtype='object')
```

In [7]:
```
df['funder'].value_counts()
```

Out[7]:
```
Government Of Tanzania    9084
Danida                    3114
Hesawa                    2202
Rwssp                     1374
World Bank                1349
                          ...
Babtest                      1
Nyangere                     1
Simango Kihengu              1
Erre Kappa                   1
Muslimu Society(shia)        1
Name: funder, Length: 1897, dtype: int64
```

In [8]:
```
df['installer'].value_counts()
```

Out[8]:
```
DWE                              17402
Government                        1825
RWE                               1206
Commu                             1060
DANIDA                            1050
                                 ...
AFRICAN REFLECTIONS FOUNDATION       1
VC                                   1
go                                   1
Gerald Mila                          1
Bonite Bottles Ltd                   1
Name: installer, Length: 2145, dtype: int64
```

In [9]:
```
df['wpt_name'].value_counts()
```

Out[9]:
```
none                    3563
Shuleni                 1748
Zahanati                 830
Msikitini                535
Kanisani                 323
                        ...
Kwa Bwana Ventura          1
Kwa Winie Msagafu          1
Kwa Timothy Mbembati       1
Sabasaba                   1
Kwa Mama Judith            1
Name: wpt_name, Length: 37400, dtype: int64
```

In [10]:
```
df['num_private'].value_counts()
```

Out[10]:
```
0      58643
6         81
1         73
5         46
8         46
       ...
180        1
213        1
23         1
55         1
94         1
Name: num_private, Length: 65, dtype: int64
```

In [11]:
```
df['basin'].value_counts()
```

Out[11]:
```
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
```

In [12]:
```
df['subvillage'].value_counts()
```

Out[12]:
```
Madukani     508
Shuleni      506
Majengo      502
Kati         373
Mtakuja      262
            ...
Bunyonya       1
Maninga        1
Mkatoni        1
Majiwe         1
Heka Kati      1
Name: subvillage, Length: 19287, dtype: int64
```

In [13]:
```
df['region'].value_counts()
```

Out[13]:
```
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
```

In [14]:
```
df['region_code'].value_counts()
```

Out[14]:
```
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      300
40       1
Name: region_code, dtype: int64
```

In [15]:
```
df['district_code'].value_counts()
```

Out[15]:
```
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
```

In [16]:
```
df['lga'].value_counts()
```

Out[16]:
```
Njombe          2503
Arusha Rural    1252
Moshi Rural     1251
Bariadi         1177
Rungwe          1106
                ...
Moshi Urban       79
Kigoma Urban      71
Arusha Urban      63
Lindi Urban       21
Nyamagana          1
Name: lga, Length: 125, dtype: int64
```

In [17]:
```
df['ward'].value_counts()
```

Out[17]:
```
Igosi               307
Imalinyi            252
Siha Kati           232
Mdandu              231
Nduruma             217
                   ...
Themi                 1
Kitete                1
Mwanga Kaskazini      1
Mawenzi               1
Korongoni             1
Name: ward, Length: 2092, dtype: int64
```

In [18]:
```
df['public_meeting'].value_counts()
```

Out[18]:
```
True     51011
False     5055
Name: public_meeting, dtype: int64
```

In [19]:
```
df['recorded_by'].value_counts()
```

Out[19]:
```
GeoData Consultants Ltd    59400
Name: recorded_by, dtype: int64
```

In [20]:
```
df['scheme_management'].value_counts()
```

Out[20]:
```
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
```

In [21]:
```
df['scheme_name'].value_counts()
```

Out[21]:
```
K                                      682
None                                   644
Borehole                               546
Chalinze wate                          405
M                                      400
                                      ...
Mwigimbi piped scheme                    1
Kakonko/Mbizi gravity water supply       1
Pwani water supply                       1
Mradi wa maji wa matalawe                1
QUICK WINDS                              1
Name: scheme_name, Length: 2696, dtype: int64
```

In [22]:
```
df['permit'].value_counts()
```

Out[22]:
```
True     38852
False    17492
Name: permit, dtype: int64
```

In [23]:
```
df['construction_year'].value_counts()
```

Out[23]:
```
0       20709
2010     2645
2008     2613
2009     2533
2000     2091
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
1980      811
1996      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
```

In [24]:
```
df['extraction_type'].value_counts()
```

Out[24]:
```
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
```

In [25]:
```
df['extraction_type_group'].value_counts()
```

Out[25]:
```
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
```

In [26]:
```
df['extraction_type_class'].value_counts()
```

Out[26]:
```
gravity         26780
handpump        16456
other            6430
submersible      6179
motorpump        2987
rope pump         451
wind-powered      117
Name: extraction_type_class, dtype: int64
```

In [27]:
```
df['management'].value_counts()
```

Out[27]:
```
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
```

In [28]:
```
df['management_group'].value_counts()
```

Out[28]:
```
user-group    52490
commercial     3638
parastatal     1768
other           943
unknown         561
Name: management_group, dtype: int64
```

In [29]:
```
df['payment'].value_counts()
```

Out[29]:
```
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
```

In [30]:
```
df['payment_type'].value_counts()
```

Out[30]:
```
never pay     25348
per bucket     8985
monthly        8300
unknown        8157
on failure     3914
annually       3642
other          1054
Name: payment_type, dtype: int64
```

In [31]:
```
df['water_quality'].value_counts()
```

Out[31]:
```
soft                  50818
salty                  4856
unknown                1876
milky                   804
coloured                490
salty abandoned         339
fluoride                200
fluoride abandoned       17
Name: water_quality, dtype: int64
```

In [32]:
```
df['quality_group'].value_counts()
```

Out[32]:
```
good        50818
salty        5195
unknown      1876
milky         804
colored       490
fluoride      217
Name: quality_group, dtype: int64
```

In [33]:
```
df['quantity'].value_counts()
```

Out[33]:
```
enough          33186
insufficient    15129
dry              6246
seasonal         4050
unknown           789
Name: quantity, dtype: int64
```

In [34]:
```
df['quantity_group'].value_counts()
```

Out[34]:
```
enough          33186
insufficient    15129
dry              6246
seasonal         4050
unknown           789
Name: quantity_group, dtype: int64
```

In [35]:
```
df['source'].value_counts()
```

Out[35]:
```
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
```

In [36]:
```
df['source_type'].value_counts()
```

Out[36]:
```
spring                  17021
shallow well            16824
borehole                11949
river/lake              10377
rainwater harvesting     2295
dam                       656
other                     278
Name: source_type, dtype: int64
```

In [37]:
```
df['source_class'].value_counts()
```

Out[37]:
```
groundwater    45794
surface        13328
unknown          278
Name: source_class, dtype: int64
```

In [38]:
```
df['waterpoint_type'].value_counts()
```

Out[38]:
```
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
```

In [39]:
```
df['waterpoint_type_group'].value_counts()
```

Out[39]:
```
communal standpipe    34624
hand pump             17488
other                  6380
improved spring         784
cattle trough           116
dam                       7
Name: waterpoint_type_group, dtype: int64
```

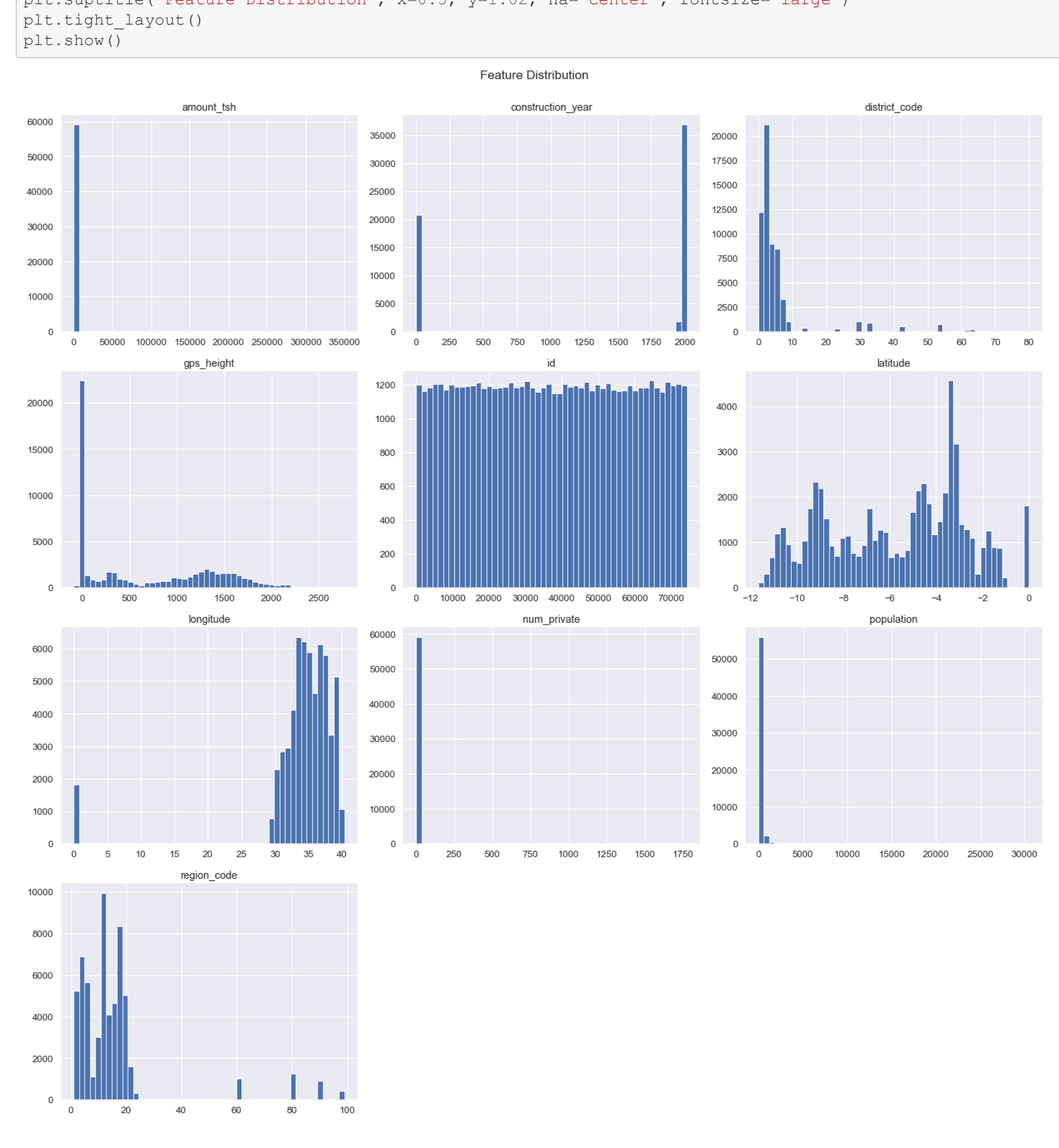
In [40]:
```
df['status_group'].value_counts()
```

Out[40]:
```
functional        32258
non functional    27141
Name: status_group, dtype: int64
```

Data Visualization

Univariate Data Exploration

In [41]:
```
df.hist(bins=50, figsize=(20,20))
plt.suptitle('Feature Distribution', x=0.5, y=1.02, ha='center', fontsize='large')
plt.tight_layout()
plt.show()
```



In [42]:
```
df.boxplot(figsize=(20,10))
plt.suptitle('BoxPlot', x=0.5, y=1.02, ha='center', fontsize='large')
plt.tight_layout()
plt.show()
```

In [43]:
```
fig = plt.figure(figsize=(20,40))

plt.subplot(7,2,1)
plt.title("Basin")
plt.xticks(rotation=45)
sns.countplot(x='basin',hue='status_group',data=df)

plt.subplot(7,2,2)
plt.title("Region")
plt.xticks(rotation=45)
sns.countplot(x='region',hue='status_group',data=df)

plt.subplot(7,2,3)
plt.title("District Code")
plt.xticks(rotation=45)
sns.countplot(x='district_code',hue='status_group',data=df)

plt.subplot(7,2,4)
plt.title("Public Meeting")
plt.xticks(rotation=45)
sns.countplot(x='public_meeting',hue='status_group',data=df)

plt.subplot(7,2,5)
plt.title("Scheme Management")
plt.xticks(rotation=45)
sns.countplot(x='scheme_management',hue='status_group',data=df)

plt.subplot(7,2,6)
plt.title("Permit")
plt.xticks(rotation=45)
sns.countplot(x='permit',hue='status_group',data=df)

plt.subplot(7,2,7)
plt.title("Extraction")
plt.xticks(rotation=45)
sns.countplot(x='extraction_type_class',hue='status_group',data=df)

plt.subplot(7,2,8)
plt.title("Management Grouping")
plt.xticks(rotation=45)
sns.countplot(x='management_group',hue='status_group',data=df)


plt.subplot(7,2,9)
plt.title("Payment Type")
plt.xticks(rotation=45)
sns.countplot(x='payment_type',hue='status_group',data=df)


plt.subplot(7,2,10)
plt.title("Quality Grouping")
plt.xticks(rotation=45)
sns.countplot(x='quality_group',hue='status_group',data=df)


plt.subplot(7,2,11)
plt.title("Quantity Grouping")
plt.xticks(rotation=45)
sns.countplot(x='quantity_group',hue='status_group',data=df)


plt.subplot(7,2,12)
plt.title("Sources")
plt.xticks(rotation=45)
sns.countplot(x='source_class',hue='status_group',data=df)


plt.subplot(7,2,13)
plt.title("Waterpoint")
plt.xticks(rotation=45)
sns.countplot(x='waterpoint_type_group',hue='status_group',data=df)


plt.subplot(7,2,14)
plt.title("Status")
plt.xticks(rotation=45)
sns.countplot(x='status_group',hue='status_group',data=df)


plt.tight_layout()
plt.show()
```

In [44]:
```
# plt.figure(figsize=(20,20))
# plt.suptitle('Pairplots of features', x=0.5, y=1.02, ha='center', fontsize='large')
# sns.pairplot(df.sample(1000))
# plt.show()
```

Drop similarly and irrelevant columns

In [45]:
```
df.columns
```

Out[45]:
```
Index(['id', 'amount_tsh', 'date_recorded', 'funder', 'gps_height', 'installer', 'longitude', 'latitude', 'wpt_name', 'num_private', 'basin', 'subvillage', 'region', 'region_code', 'district_code', 'lga', 'ward', 'population', 'public_meeting', 'recorded_by', 'scheme_management', 'scheme_name', 'permit', 'construction_year', 'extraction_type', 'extraction_type_group', 'extraction_type_class', 'management', 'management_group', 'payment', 'payment_type', 'water_quality', 'quality_group', 'quantity', 'quantity_group', 'source', 'source_type', 'source_class', 'waterpoint_type', 'waterpoint_type_group', 'status_group'], dtype='object')
```

In [46]:
```
df.drop(['id','date_recorded', 'funder', 'gps_height', 'installer', 'longitude', 'latitude',
        'wpt_name', 'num_private','subvillage', 'region', 'region_code', 'district_code', 'lga', 'ward'
,
        'recorded_by','scheme_name','extraction_type', 'extraction_type_group','management',
        'payment','water_quality','quantity','source', 'source_type','waterpoint_type'],axis=1,inplace=
True)
```

In [47]:
```
df
```

Out[47]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	construction_year	extraction_type_class	manage
0	6000.0	Lake Nyasa	109	True	VWC	False	1999	gravity	
1	0.0	Lake Victoria	280	NaN	Other	True	2010	gravity	
2	25.0	Pangani	250	True	VWC	True	2009	gravity	
3	0.0	Ruvuma / Southern Coast	58	True	VWC	True	1986	submersible	
4	0.0	Lake Victoria	0	True	NaN	True	0	gravity	
...	...	...	...	...	...	...	...	...	
59395	10.0	Pangani	125	True	Water Board	True	1999	gravity	
59396	4700.0	Rufiji	56	True	VWC	True	1996	gravity	
59397	0.0	Rufiji	0	True	VWC	False	0	handpump	
59398	0.0	Rufiji	0	True	VWC	True	0	handpump	
59399	0.0	Wami / Ruvu	150	True	VWC	True	2002	handpump	

59400 rows × 15 columns

In [48]:
```
#Save to csv
#df.to_csv("train1.csv",index=False)
```

In [49]:
```
df["construction_year"] = df["construction_year"].replace(to_replace=0, value=np.nan)
```

In [50]:
```
df
```

Out[50]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	construction_year	extraction_type_class	manage
0	6000.0	Lake Nyasa	109	True	VWC	False	1999.0	gravity	
1	0.0	Lake Victoria	280	NaN	Other	True	2010.0	gravity	
2	25.0	Pangani	250	True	VWC	True	2009.0	gravity	
3	0.0	Ruvuma / Southern Coast	58	True	VWC	True	1986.0	submersible	
4	0.0	Lake Victoria	0	True	NaN	True	NaN	gravity	
...	...	...	...	...	...	...	...	...	
59395	10.0	Pangani	125	True	Water Board	True	1999.0	gravity	
59396	4700.0	Rufiji	56	True	VWC	True	1996.0	gravity	
59397	0.0	Rufiji	0	True	VWC	False	NaN	handpump	
59398	0.0	Rufiji	0	True	VWC	True	NaN	handpump	
59399	0.0	Wami / Ruvu	150	True	VWC	True	2002.0	handpump	

59400 rows × 15 columns

In [51]:
```
df['age'] = 2020 - df["construction_year"]
```

In [52]:
```
df
```

Out[52]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	construction_year	extraction_type_class	manage
0	6000.0	Lake Nyasa	109	True	VWC	False	1999.0	gravity	
1	0.0	Lake Victoria	280	NaN	Other	True	2010.0	gravity	
2	25.0	Pangani	250	True	VWC	True	2009.0	gravity	
3	0.0	Ruvuma / Southern Coast	58	True	VWC	True	1986.0	submersible	
4	0.0	Lake Victoria	0	True	NaN	True	NaN	gravity	
...	...	...	...	...	...	...	...	...	
59395	10.0	Pangani	125	True	Water Board	True	1999.0	gravity	
59396	4700.0	Rufiji	56	True	VWC	True	1996.0	gravity	
59397	0.0	Rufiji	0	True	VWC	False	NaN	handpump	
59398	0.0	Rufiji	0	True	VWC	True	NaN	handpump	
59399	0.0	Wami / Ruvu	150	True	VWC	True	2002.0	handpump	

59400 rows × 16 columns

In [53]:
```
df.drop(['construction_year'],axis=1,inplace=True)
```

In [54]:
```
df
```

Out[54]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	extraction_type_class	management_group	payme
0	6000.0	Lake Nyasa	109	True	VWC	False	gravity	user-group	
1	0.0	Lake Victoria	280	NaN	Other	True	gravity	user-group	ne
2	25.0	Pangani	250	True	VWC	True	gravity	user-group	pe
3	0.0	Ruvuma / Southern Coast	58	True	VWC	True	submersible	user-group	ne
4	0.0	Lake Victoria	0	True	NaN	True	gravity	other	ne
...	...	...	...	...	...	...	...	...	
59395	10.0	Pangani	125	True	Water Board	True	gravity	user-group	pe
59396	4700.0	Rufiji	56	True	VWC	True	gravity	user-group	
59397	0.0	Rufiji	0	True	VWC	False	handpump	user-group	
59398	0.0	Rufiji	0	True	VWC	True	handpump	user-group	ne
59399	0.0	Wami / Ruvu	150	True	VWC	True	handpump	user-group	o

59400 rows × 15 columns

In [55]:
```
#Save to csv
#df.to_csv("train2.csv",index=False)
```

In [56]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 59400 entries, 0 to 59399
Data columns (total 15 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   amount_tsh             59400 non-null  float64
 1   basin                  59400 non-null  object
 2   population             59400 non-null  int64
 3   public_meeting         56066 non-null  object
 4   scheme_management      55523 non-null  object
 5   permit                 56344 non-null  object
 6   extraction_type_class  59400 non-null  object
 7   management_group       59400 non-null  object
 8   payment_type           59400 non-null  object
 9   quality_group          59400 non-null  object
 10  quantity_group         59400 non-null  object
 11  source_class           59400 non-null  object
 12  waterpoint_type_group  59399 non-null  object
 13  status_group           59399 non-null  object
 14  age                    38691 non-null  float64
dtypes: float64(2), int64(1), object(12)
memory usage: 6.8+ MB
```

Treat Missing Values

In [57]:
```
df.isnull().sum()
```

Out[57]:
```
amount_tsh                   0
basin                        0
population                   0
public_meeting            3334
scheme_management         3877
permit                    3056
extraction_type_class        0
management_group             0
payment_type                 0
quality_group                0
quantity_group               0
source_class                 0
waterpoint_type_group        1
status_group                 1
age                      20709
dtype: int64
```

In [58]:
```
df.dropna(inplace=True)
```

In [59]:
```
df.isnull().sum()
```

Out[59]:
```
amount_tsh               0
basin                    0
population               0
public_meeting           0
scheme_management        0
permit                   0
extraction_type_class    0
management_group         0
payment_type             0
quality_group            0
quantity_group           0
source_class             0
waterpoint_type_group    0
status_group             0
age                      0
dtype: int64
```

In [60]:
```
df
```

Out[60]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	extraction_type_class	management_group	payme
0	6000.0	Lake Nyasa	109	True	VWC	False	gravity	user-group	
2	25.0	Pangani	250	True	VWC	True	gravity	user-group	pe
3	0.0	Ruvuma / Southern Coast	58	True	VWC	True	submersible	user-group	ne
5	20.0	Pangani	1	True	VWC	True	submersible	user-group	pe
10	0.0	Wami / Ruvu	345	True	Private operator	False	submersible	commercial	ne
...	...	...	...	...	...	...	...	...	
59391	0.0	Pangani	210	True	Water authority	True	gravity	user-group	ne
59394	500.0	Wami / Ruvu	89	True	VWC	True	submersible	user-group	
59395	10.0	Pangani	125	True	Water Board	True	gravity	user-group	pe
59396	4700.0	Rufiji	56	True	VWC	True	gravity	user-group	
59399	0.0	Wami / Ruvu	150	True	VWC	True	handpump	user-group	o

32514 rows × 15 columns

In [61]:
```
df.reset_index(drop=True,inplace=True)
```

In [62]:
```
df
```

Out[62]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	extraction_type_class	management_group	payme
0	6000.0	Lake Nyasa	109	True	VWC	False	gravity	user-group	
1	25.0	Pangani	250	True	VWC	True	gravity	user-group	pe
2	0.0	Ruvuma / Southern Coast	58	True	VWC	True	submersible	user-group	ne
3	20.0	Pangani	1	True	VWC	True	submersible	user-group	pe
4	0.0	Wami / Ruvu	345	True	Private operator	False	submersible	commercial	ne
...	...	...	...	...	...	...	...	...	
32509	0.0	Pangani	210	True	Water authority	True	gravity	user-group	ne
32510	500.0	Wami / Ruvu	89	True	VWC	True	submersible	user-group	
32511	10.0	Pangani	125	True	Water Board	True	gravity	user-group	pe
32512	4700.0	Rufiji	56	True	VWC	True	gravity	user-group	
32513	0.0	Wami / Ruvu	150	True	VWC	True	handpump	user-group	o

32514 rows × 15 columns

In [63]:
```
#Save to csv
#df.to_csv("train3.csv",index=False)
```

Correlation

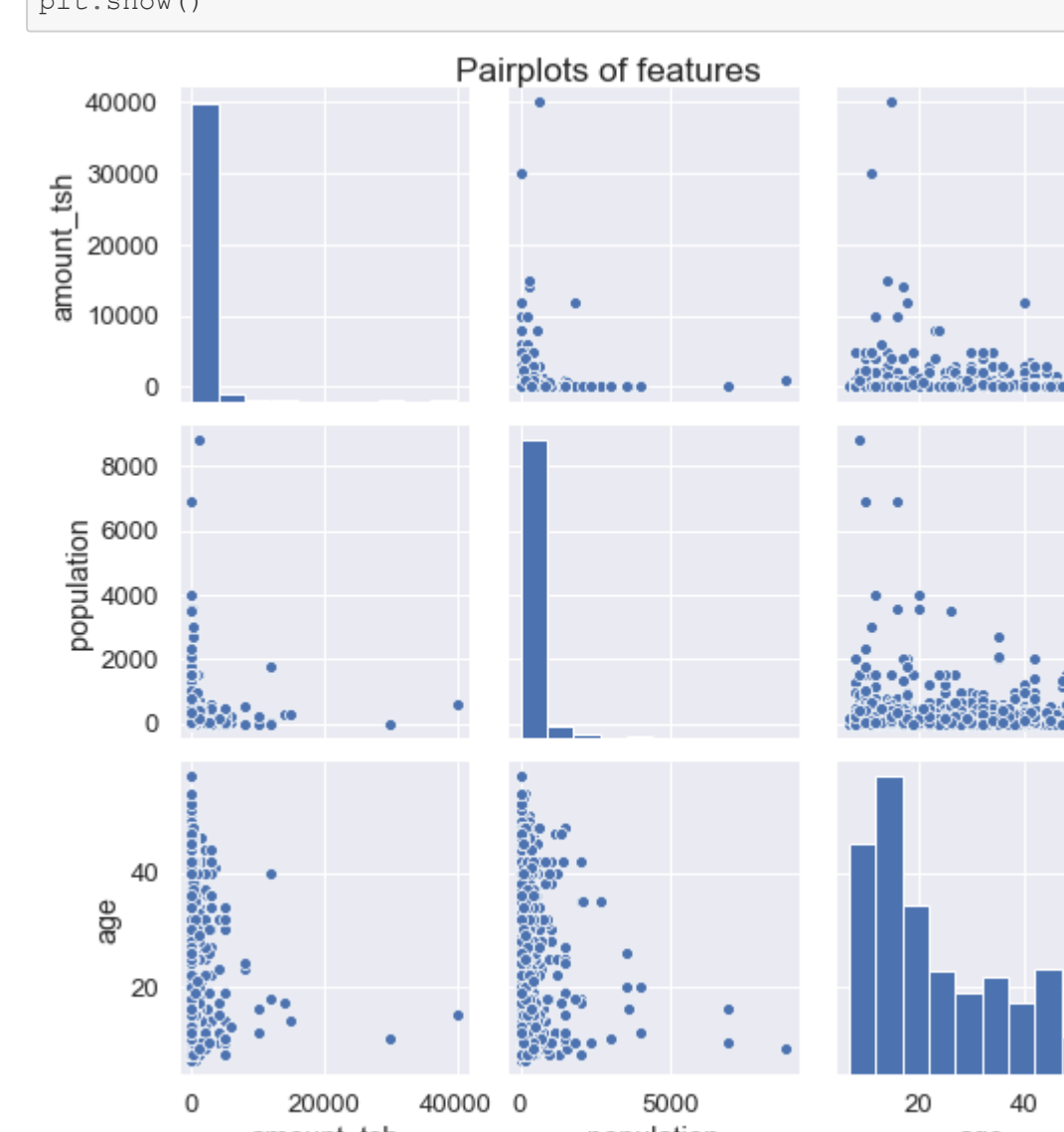
In [64]:
```
df.corr()
```

Out[64]:

	amount_tsh	population	age
amount_tsh	1.000000	-0.007501	-0.008418
population	-0.007501	1.000000	-0.023285
age	-0.008418	-0.023285	1.000000

In [65]:
```
plt.figure(figsize=(16,5))
sns.heatmap(df.corr(),cmap="coolwarm",annot=True,fmt='.2f',linewidths=2)
plt.show()
```

In [66]:
```
sns.pairplot(df[['amount_tsh','population','age']].sample(1000))
plt.suptitle('Pairplots of features', x=0.5, y=1.02, ha='center', fontsize='large')
plt.show()
```



Treat Duplicate Values

In [67]:
```
df.duplicated(keep='first').sum()
```

Out[67]:
```
9658
```

In [68]:
```
df[df.duplicated(keep=False)] #Check duplicate values
```

Out[68]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	extraction_type_class	management_group	payr
0	6000.0	Lake Nyasa	109	True	VWC	False	gravity	user-group	
1	25.0	Pangani	250	True	VWC	True	gravity	user-group	
6	0.0	Pangani	1	True	Water Board	True	gravity	user-group	
7	0.0	Lake Tanganyika	200	True	VWC	False	handpump	user-group	
9	0.0	Rufiji	50	True	WUA	True	gravity	user-group	
...	...	...	...	...	...	...	...	...	
32493	0.0	Lake Rukwa	1	False	VWC	False	handpump	user-group	
32497	2000.0	Lake Nyasa	0	True	VWC	False	gravity	user-group	
32503	6.0	Pangani	1	True	Water Board	True	gravity	user-group	
32509	0.0	Pangani	210	True	Water authority	True	gravity	user-group	
32511	10.0	Pangani	125	True	Water Board	True	gravity	user-group	

13039 rows × 15 columns

Treat Outliers

In [69]:
```
df.columns
```

Out[69]:
```
Index(['amount_tsh', 'basin', 'population', 'public_meeting', 'scheme_management', 'permit', 'extraction_type_class', 'management_group', 'payment_type', 'quality_group', 'quantity_group', 'source_class', 'waterpoint_type_group', 'status_group', 'age'], dtype='object')
```

In [70]:
```
df.describe()
```

Out[70]:

	amount_tsh	population	age
count	32514.000000	32514.000000	32514.000000
mean	515.297933	257.588639	23.270776
std	3235.720694	548.275049	12.604989
min	0.000000	0.000000	7.000000
25%	0.000000	25.000000	12.000000
50%	0.000000	130.000000	20.000000
75%	250.000000	300.000000	34.000000
max	250000.000000	30500.000000	60.000000

In [71]:
```
windsorizer = Winsorizer(distribution='skewed',tail='right',fold=3.0, variables=['amount_tsh','population'])
```

In [72]:
```
windsorizer.fit(df)
```

Out[72]:
```
Winsorizer(distribution='skewed', fold=3.0,
           variables=['amount_tsh', 'population'])
```

In [73]:
```
df2 = windsorizer.transform(df)
```

In [74]:
```
df2
```

Out[74]:

	amount_tsh	basin	population	public_meeting	scheme_management	permit	extraction_type_class	management_group	payme
0	1000.0	Lake Nyasa	109.0	True	VWC	False	gravity	user-group	
1	25.0	Pangani	250.0	True	VWC	True	gravity	user-group	pe
2	0.0	Ruvuma / Southern Coast	58.0	True	VWC	True	submersible	user-group	ne
3	20.0	Pangani	1.0	True	VWC	True	submersible	user-group	pe
4	0.0	Wami / Ruvu	345.0	True	Private operator	False	submersible	commercial	ne
...	...	...	...	...	...	...	...	...	
32509	0.0	Pangani	210.0	True	Water authority	True	gravity	user-group	ne
32510	500.0	Wami / Ruvu	89.0	True	VWC	True	submersible	user-group	
32511	10.0	Pangani	125.0	True	Water Board	True	gravity	user-group	pe
32512	1000.0	Rufiji	56.0	True	VWC	True	gravity	user-group	
32513	0.0	Wami / Ruvu	150.0	True	VWC	True	handpump	user-group	c

32514 rows × 15 columns

In [75]:
```
df2.describe()
```

Out[75]:

	amount_tsh	population	age
count	32514.000000	32514.000000	32514.000000
mean	195.524912	217.319893	23.270776
std	339.119814	263.161043	12.604989
min	0.000000	0.000000	7.000000
25%	0.000000	25.000000	12.000000
50%	0.000000	130.000000	20.000000
75%	250.000000	300.000000	34.000000
max	1000.000000	1125.000000	60.000000

In [76]:
```
windsorizer.left_tail_caps_
```

Out[76]:
```
{}
```

In [77]:
```
windsorizer.right_tail_caps_
```

Out[77]:
```
{'amount_tsh': 1000.0, 'population': 1125.0}
```

In [78]:
```
#Save to csv
#df2.to_csv("train4.csv",index=False)
```

In [79]:
```
df2.columns
```

Out[79]:
```
Index(['amount_tsh', 'basin', 'population', 'public_meeting', 'scheme_management', 'permit', 'extraction_type_class', 'management_group', 'payment_type', 'quality_group', 'quantity_group', 'source_class', 'waterpoint_type_group', 'status_group', 'age'], dtype='object')
```

In [80]:
```
#Rearrange columns
df2 = df2[['amount_tsh','age','population','basin','public_meeting', 'scheme_management', 'permit',
        'extraction_type_class', 'management_group', 'payment_type', 'quality_group', 'quantity_grou
p',
        'source_class', 'waterpoint_type_group', 'status_group']]
```

In [81]:
```
df2
```

Out[81]:

	amount_tsh	age	population	basin	public_meeting	scheme_management	permit	extraction_type_class	management_group
0	1000.0	21.0	109.0	Lake Nyasa	True	VWC	False	gravity	user-group
1	25.0	11.0	250.0	Pangani	True	VWC	True	gravity	user-group
2	0.0	34.0	58.0	Ruvuma / Southern Coast	True	VWC	True	submersible	user-group
3	20.0	11.0	1.0	Pangani	True	VWC	True	submersible	user-group
4	0.0	9.0	345.0	Wami / Ruvu	True	Private operator	False	submersible	commercial
...	...	...	...	...	...	...	...	...	...
32509	0.0	53.0	210.0	Pangani	True	Water authority	True	gravity	user-group
32510	500.0	13.0	89.0	Wami / Ruvu	True	VWC	True	submersible	user-group
32511	10.0	21.0	125.0	Pangani	True	Water Board	True	gravity	user-group
32512	1000.0	24.0	56.0	Rufiji	True	VWC	True	gravity	user-group
32513	0.0	18.0	150.0	Wami / Ruvu	True	VWC	True	handpump	user-group

32514 rows × 15 columns

Transform label

In [82]:
```
encoder = LabelEncoder()
```

In [83]:
```
df2["status_group"] = encoder.fit_transform(df2["status_group"])
```

In [84]:
```
df2 # 0 is functional, 1 is non-functional
```

Out[84]:

	amount_tsh	age	population	basin	public_meeting	scheme_management	permit	extraction_type_class	management_group
0	1000.0	21.0	109.0	Lake Nyasa	True	VWC	False	gravity	user-group
1	25.0	11.0	250.0	Pangani	True	VWC	True	gravity	user-group
2	0.0	34.0	58.0	Ruvuma / Southern Coast	True	VWC	True	submersible	user-group
3	20.0	11.0	1.0	Pangani	True	VWC	True	submersible	user-group
4	0.0	9.0	345.0	Wami / Ruvu	True	Private operator	False	submersible	commercial
...	...	...	...	...	...	...	...	...	...
32509	0.0	53.0	210.0	Pangani	True	Water authority	True	gravity	user-group
32510	500.0	13.0	89.0	Wami / Ruvu	True	VWC	True	submersible	user-group
32511	10.0	21.0	125.0	Pangani	True	Water Board	True	gravity	user-group
32512	1000.0	24.0	56.0	Rufiji	True	VWC	True	gravity	user-group
32513	0.0	18.0	150.0	Wami / Ruvu	True	VWC	True	handpump	user-group

32514 rows × 15 columns

In [85]:
```
#Save to csv
#df2.to_csv("train5.csv",index=False)
```

Perform One-Hot Encoding

In [86]:
```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 32514 entries, 0 to 32513
Data columns (total 15 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   amount_tsh             32514 non-null  float64
 1   age                    32514 non-null  float64
 2   population             32514 non-null  float64
 3   basin                  32514 non-null  object 
 4   public_meeting         32514 non-null  object 
 5   scheme_management      32514 non-null  object 
 6   permit                 32514 non-null  object 
 7   extraction_type_class  32514 non-null  object 
 8   management_group       32514 non-null  object 
 9   payment_type           32514 non-null  object 
 10  quality_group          32514 non-null  object 
 11  quantity_group         32514 non-null  object 
 12  source_class           32514 non-null  object 
 13  waterpoint_type_group  32514 non-null  object 
 14  status_group           32514 non-null  int32  
dtypes: float64(3), int32(1), object(11)
memory usage: 3.6+ MB
```

In [87]:
```
df3 = pd.get_dummies(df2,drop_first=True)
```

In [88]:
```
df3
```

Out[88]:

	amount_tsh	age	population	status_group	basin_Lake Nyasa	basin_Lake Rukwa	basin_Lake Tanganyika	basin_Lake Victoria	basin_Pangani	basin_Rufiji	basin_ / S
0	1000.0	21.0	109.0	0	1	0	0	0	0	0	
1	25.0	11.0	250.0	0	0	0	0	0	1	0	
2	0.0	34.0	58.0	1	0	0	0	0	0	0	
3	20.0	11.0	1.0	0	0	0	0	0	1	0	
4	0.0	9.0	345.0	0	0	0	0	0	0	0	
...	...	...	...	...	...	...	...	...	...	...	
32509	0.0	53.0	210.0	1	0	0	0	0	1	0	
32510	500.0	13.0	89.0	1	0	0	0	0	0	0	
32511	10.0	21.0	125.0	0	0	0	0	0	1	0	
32512	1000.0	24.0	56.0	0	0	0	0	0	0	1	
32513	0.0	18.0	150.0	0	0	0	0	0	0	0	

32514 rows × 57 columns

In [89]:
```
df3.columns
```

Out[89]:
```
Index(['amount_tsh', 'age', 'population', 'status_group', 'basin_Lake Nyasa', 'basin_Lake Rukwa', 'ba
sin_Lake Tanganyika', 'basin_Lake Victoria', 'basin_Pangani', 'basin_Rufiji', 'basin_Ruvuma / Souther
n Coast', 'basin_Wami / Ruvu', 'public_meeting_True', 'scheme_management_None', 'scheme_management_Ot
her', 'scheme_management_Parastatal', 'scheme_management_Private operator', 'scheme_management_SWC',
'scheme_management_Trust', 'scheme_management_VWC', 'scheme_management_WUA', 'scheme_management_WUG',
'scheme_management_Water Board', 'scheme_management_Water authority', 'permit_True', 'extraction_type
_class_handpump', 'extraction_type_class_motorpump', 'extraction_type_class_other', 'extraction_type_
class_rope pump', 'extraction_type_class_submersible', 'extraction_type_class_wind-powered', 'managem
ent_group_other', 'management_group_parastatal', 'management_group_unknown', 'management_group_user-g
roup', 'payment_type_monthly', 'payment_type_never pay', 'payment_type_on failure',
       'payment_type_other', 'payment_type_per bucket', 'payment_type_unknown', 'quality_group_fluori
de', 'quality_group_good', 'quality_group_milky', 'quality_group_salty', 'quality_group_unknown', 'qu
antity_group_enough', 'quantity_group_insufficient', 'quantity_group_seasonal', 'quantity_group_unkno
wn', 'source_class_surface', 'source_class_unknown', 'waterpoint_type_group_communal standpipe', 'wat
erpoint_type_group_dam', 'waterpoint_type_group_hand pump', 'waterpoint_type_group_improved spring',
'waterpoint_type_group_other'],
      dtype='object')
```

In [90]:
```
df3 = df3[['amount_tsh', 'age', 'population','basin_Lake Nyasa', 'basin_Lake Rukwa', 'basin_Lake Tangan
yika', 'basin_Lake Victoria', 'basin_Pangani', 'basin_Rufiji', 'basin_Ruvuma / Southern Coast', 'basin_
Wami / Ruvu', 'public_meeting_True', 'scheme_management_None', 'scheme_management_Other', 'scheme_manag
ement_Parastatal', 'scheme_management_Private operator', 'scheme_management_SWC', 'scheme_management_Tr
ust', 'scheme_management_VWC', 'scheme_management_WUA', 'scheme_management_WUG', 'scheme_management_Wat
er Board',
           'scheme_management_Water authority', 'permit_True', 'extraction_type_class_handpump', 'extra
ction_type_class_motorpump',
           'extraction_type_class_other', 'extraction_type_class_rope pump', 'extraction_type_class_sub
mersible',
           'extraction_type_class_wind-powered', 'management_group_other', 'management_group_parastata
l',
           'management_group_unknown', 'management_group_user-group', 'payment_type_monthly',
           'payment_type_never pay', 'payment_type_on failure','payment_type_other', 'payment_type_per
 bucket',
           'payment_type_unknown', 'quality_group_fluoride', 'quality_group_good', 'quality_group_milk
y',
           'quality_group_salty', 'quality_group_unknown', 'quantity_group_enough', 'quantity_group_ins
ufficient',
           'quantity_group_seasonal', 'quantity_group_unknown', 'source_class_surface', 'source_class_u
nknown',
           'waterpoint_type_group_communal standpipe', 'waterpoint_type_group_dam',
           'waterpoint_type_group_hand pump', 'waterpoint_type_group_improved spring',
           'waterpoint_type_group_other', 'status_group']]
```

In [91]:
```
df3
```

Out[91]:

	amount_tsh	age	population	basin_Lake Nyasa	basin_Lake Rukwa	basin_Lake Tanganyika	basin_Lake Victoria	basin_Pangani	basin_Rufiji	basin_Ruvuma / Southern Coast	basi
0	1000.0	21.0	109.0	1	0	0	0	0	0	0	
1	25.0	11.0	250.0	0	0	0	0	1	0	0	
2	0.0	34.0	58.0	0	0	0	0	0	0	1	
3	20.0	11.0	1.0	0	0	0	0	1	0	0	
4	0.0	9.0	345.0	0	0	0	0	0	0	0	
...	...	...	...	...	...	...	...	...	...	...	
32509	0.0	53.0	210.0	0	0	0	0	1	0	0	
32510	500.0	13.0	89.0	0	0	0	0	0	0	0	
32511	10.0	21.0	125.0	0	0	0	0	1	0	0	
32512	1000.0	24.0	56.0	0	0	0	0	0	1	0	
32513	0.0	18.0	150.0	0	0	0	0	0	0	0	

32514 rows × 57 columns

In [92]:
```
#Save to csv
#df3.to_csv("train5.csv",index=False)
```

In [ ]: