In [94]:
```
# This Python 3 environment comes with many helpful analytics libraries i
# It is defined by the kaggle/python Docker image: https://github.com/kag
# For example, here's several helpful packages to load

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the read-only "../input/" directory
# For example, running this (by clicking run or pressing Shift+Enter) wil

import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

# You can write up to 20GB to the current directory (/kaggle/working/) th
# You can also write temporary files to /kaggle/temp/, but they won't be
```

```
/kaggle/input/pakistan-crop-production-and-yield-data19612023/
FAOSTAT_data_en_9-7-2025.csv
```

Importing Libraries

In [95]:
```
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
```

Reading the dataset from Kaggle

In [96]:
```
df = pd.read_csv('/kaggle/input/pakistan-crop-production-and-yield-data19
df.head()
```

```
/usr/local/lib/python3.11/dist-packages/pandas/io/formats/format.py:1458:
RuntimeWarning: invalid value encountered in greater
  has_large_values = (abs_vals > 1e6).any()
/usr/local/lib/python3.11/dist-packages/pandas/io/formats/format.py:1459:
RuntimeWarning: invalid value encountered in less
  has_small_values = ((abs_vals < 10 ** (-self.digits)) & (abs_vals > 0)).any
/usr/local/lib/python3.11/dist-packages/pandas/io/formats/format.py:1459:
RuntimeWarning: invalid value encountered in greater
  has_small_values = ((abs_vals < 10 ** (-self.digits)) & (abs_vals > 0)).any
```

Out[96]:

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code (CPC)	Item	Year Code	Year	Un
0	QCL	Crops and livestock products	586	Pakistan	5412	Yield	112.0	Maize (corn)	1961	1961	kç h
1	QCL	Crops and livestock products	586	Pakistan	5510	Production	112.0	Maize (corn)	1961	1961	
2	QCL	Crops and livestock products	586	Pakistan	5412	Yield	112.0	Maize (corn)	1962	1962	kç h
3	QCL	Crops and livestock products	586	Pakistan	5510	Production	112.0	Maize (corn)	1962	1962	
4	QCL	Crops and livestock products	586	Pakistan	5412	Yield	112.0	Maize (corn)	1963	1963	kç h

Filtering Irrelvant Attributes

- Domain Code and domain are irrelevant and non unique
- Area and Area Code are irrelevant and non unique
- Note is Null for most of the Dataset
- Year Code and Year are related hence Year Code was dropped
- Element Code and Year are related hence Element was dropped
- Same for Item code
- Flag Description and Flag are same

In [109…

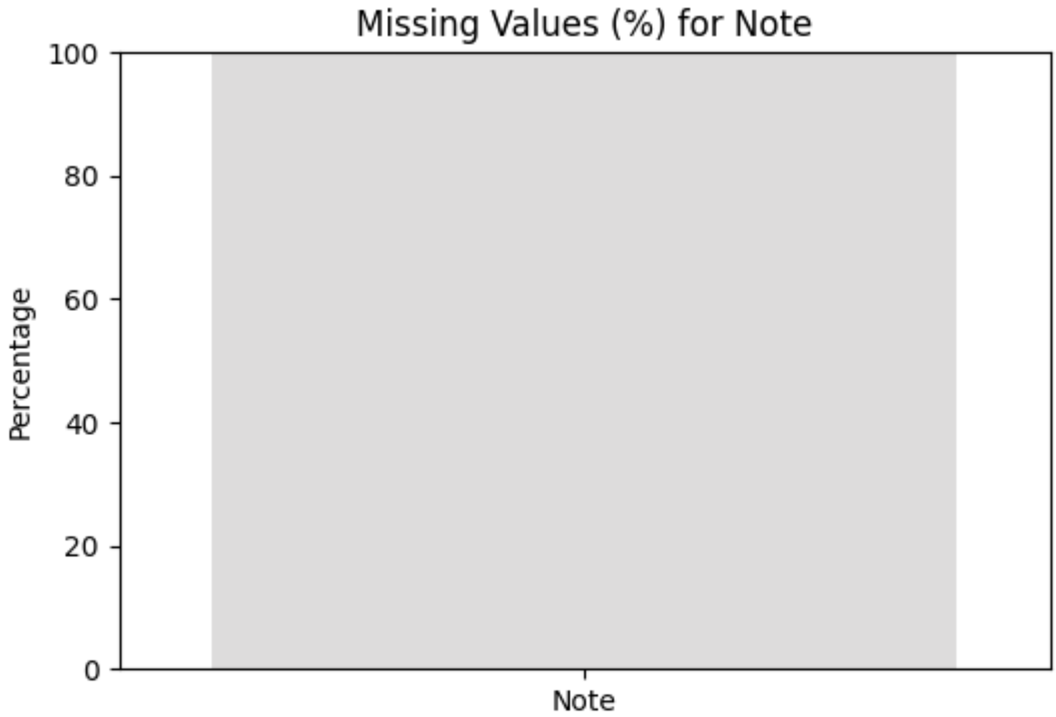
```
import matplotlib.pyplot as plt
import seaborn as sns

# Column mostly null
col = 'Note'

missing_percent = df[col].isnull().mean() * 100

plt.figure(figsize=(6,4))
sns.barplot(x=[col], y=[missing_percent], palette="coolwarm")
plt.title(f'Missing Values (%) for {col}')
plt.ylim(0,100)
plt.ylabel('Percentage')
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1765: FutureWarni
unique with argument that is not not a Series, Index, ExtensionArray, or np.n
is deprecated and will raise in a future version.
  order = pd.unique(vector)
/usr/local/lib/python3.11/dist-packages/seaborn/categorical.py:645: FutureWar
When grouping with a length-1 list-like, you will need to pass a length-1 tup
get_group in a future version of pandas. Pass `(name,)` instead of `name` to
silence this warning.
  g_vals = grouped_vals.get_group(g)
```



In [110…

```
cols_non_unique = ['Domain Code', 'Domain', "Area", "Area Code (M49)"]

for col in cols_non_unique:
    unique_percent = df[col].nunique() / len(df) * 100

    plt.figure(figsize=(6,4))
    sns.barplot(x=[col], y=[unique_percent], palette="magma")
    plt.title(f'Uniqueness (%) for {col}')
    plt.ylim(0,100)
    plt.ylabel('Percentage of Unique Values')
    plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1765: FutureWarni
unique with argument that is not not a Series, Index, ExtensionArray, or np.n
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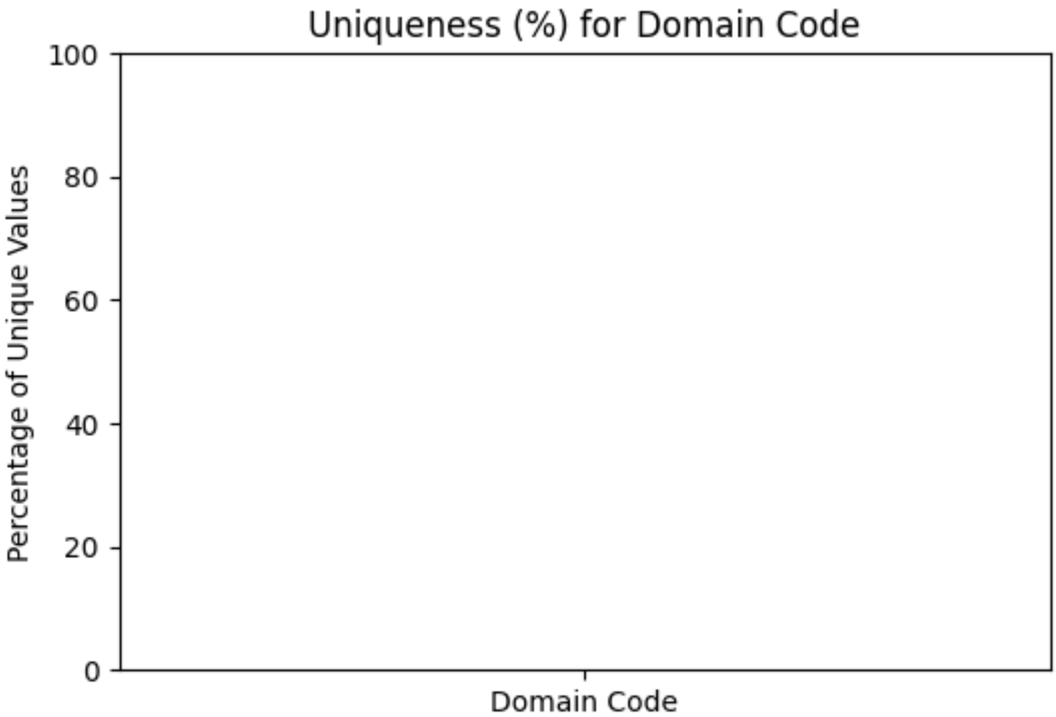


```
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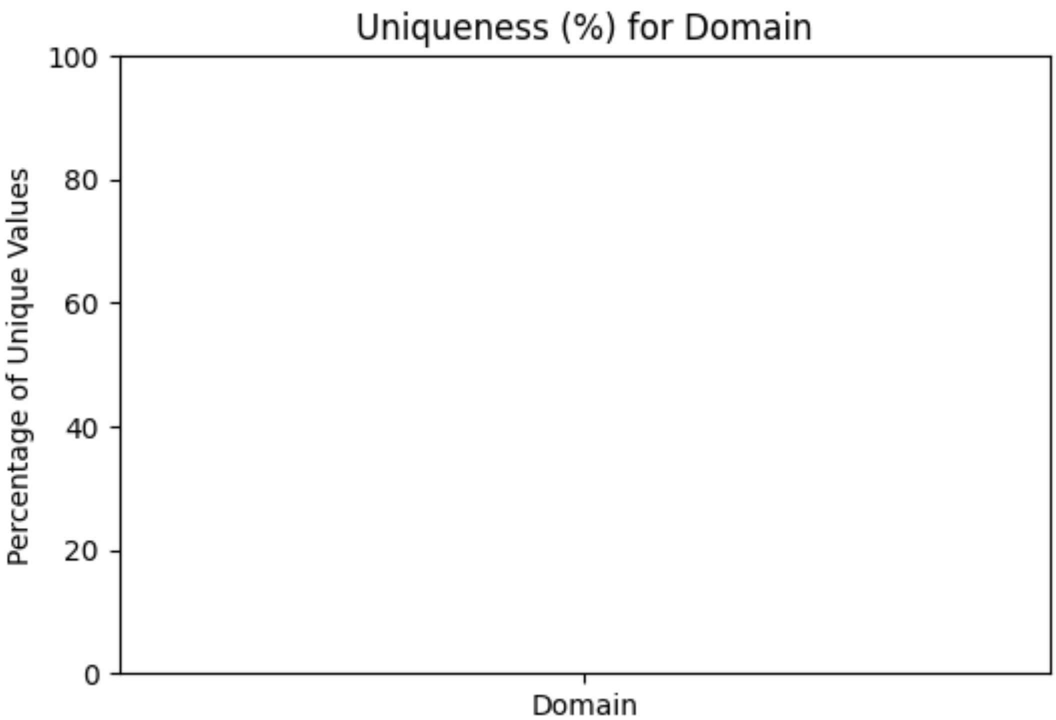

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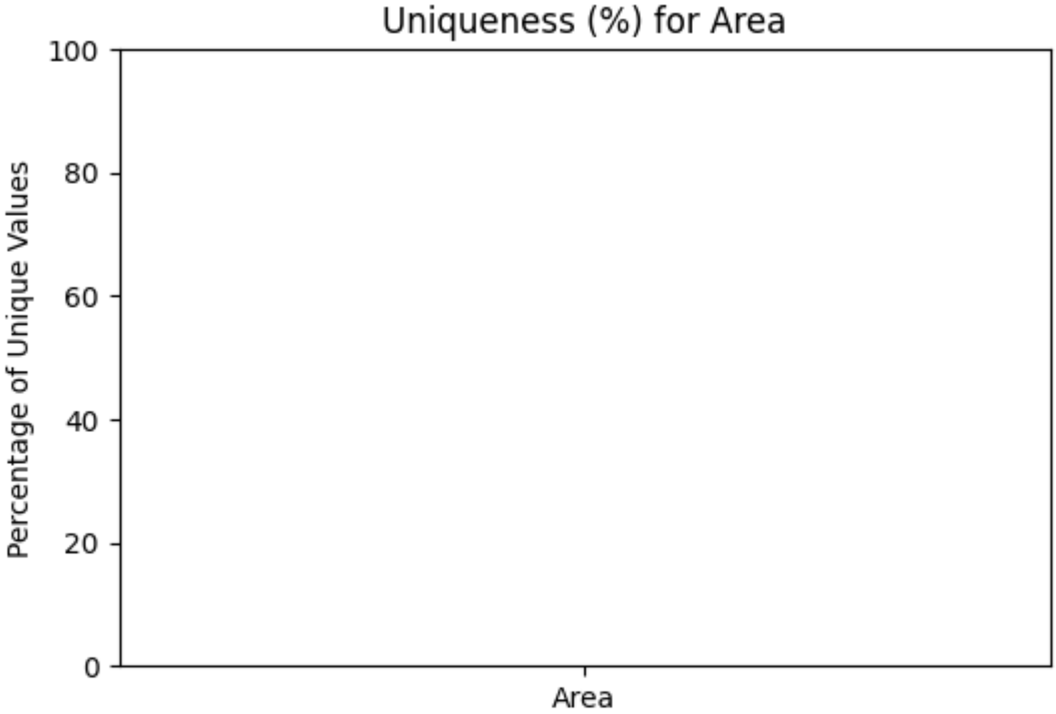


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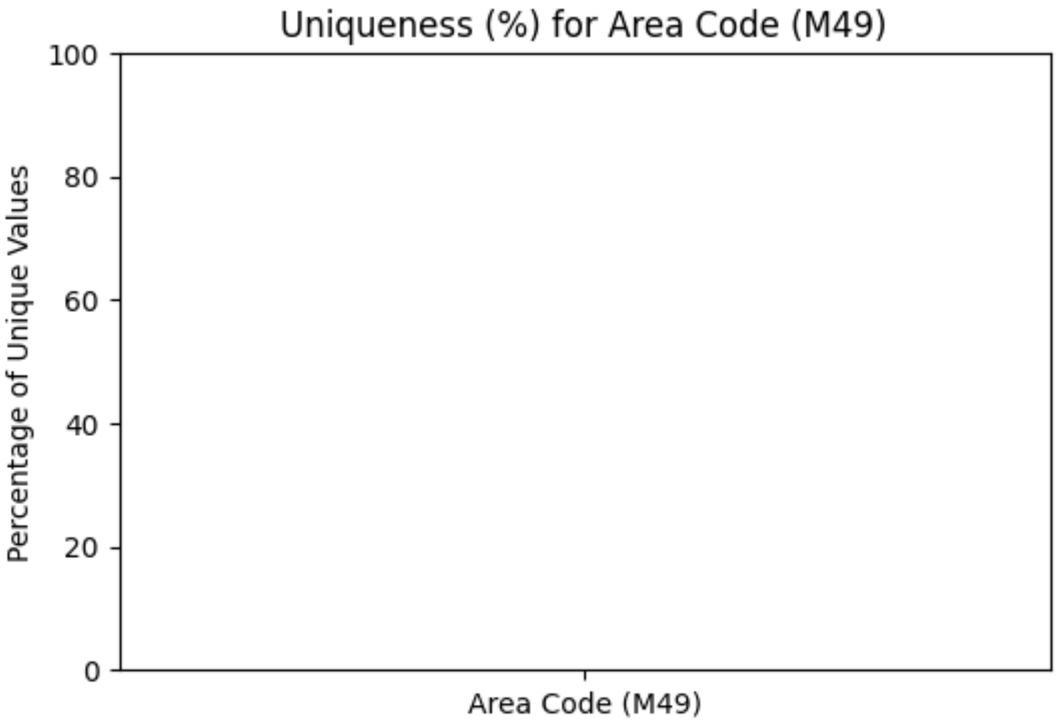


```
In [111… redundant_pairs = {
             'Year Code': 'Year',
             'Element Code': 'Element',
             'Item Code (CPC)': 'Item',
             'Flag Description': 'Flag'
         }

         for col, related_col in redundant_pairs.items():
             unique_comb = df[[col, related_col]].drop_duplicates().shape[0]
             total_rows = len(df)
             redundancy_percent = 100 - (unique_comb / total_rows * 100)

             plt.figure(figsize=(6,4))
             sns.barplot(x=[col], y=[redundancy_percent], palette="viridis")
             plt.title(f'Redundancy with {related_col} (%) for {col}')
             plt.ylim(0,100)
             plt.ylabel('Percentage of Redundant Rows')
             plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1765: FutureWarni
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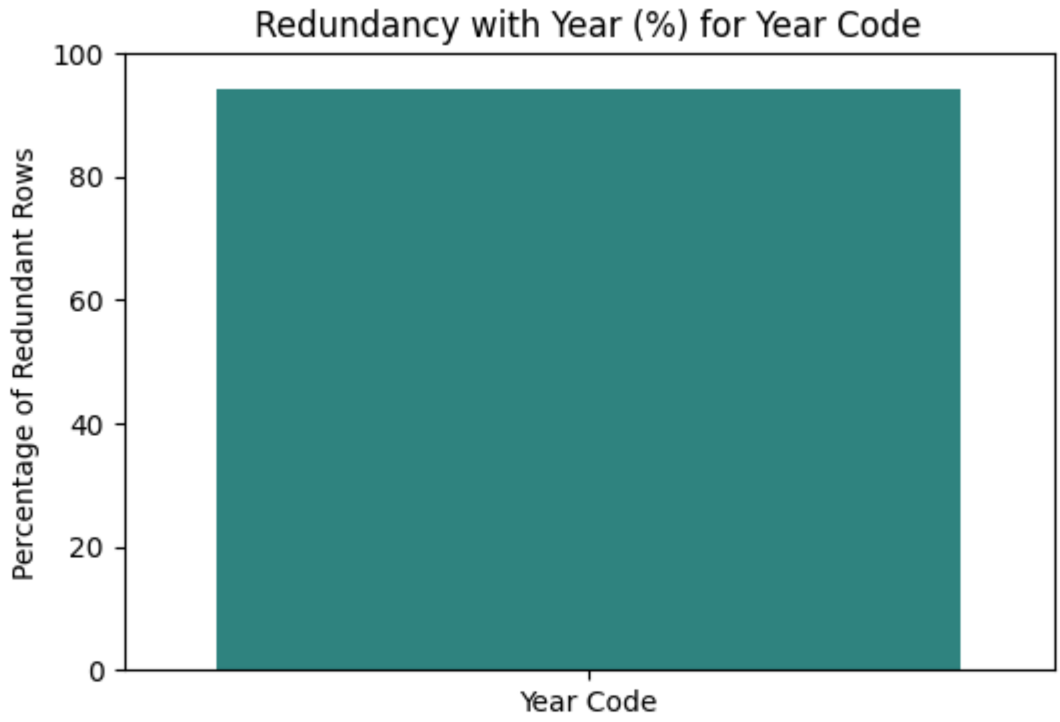


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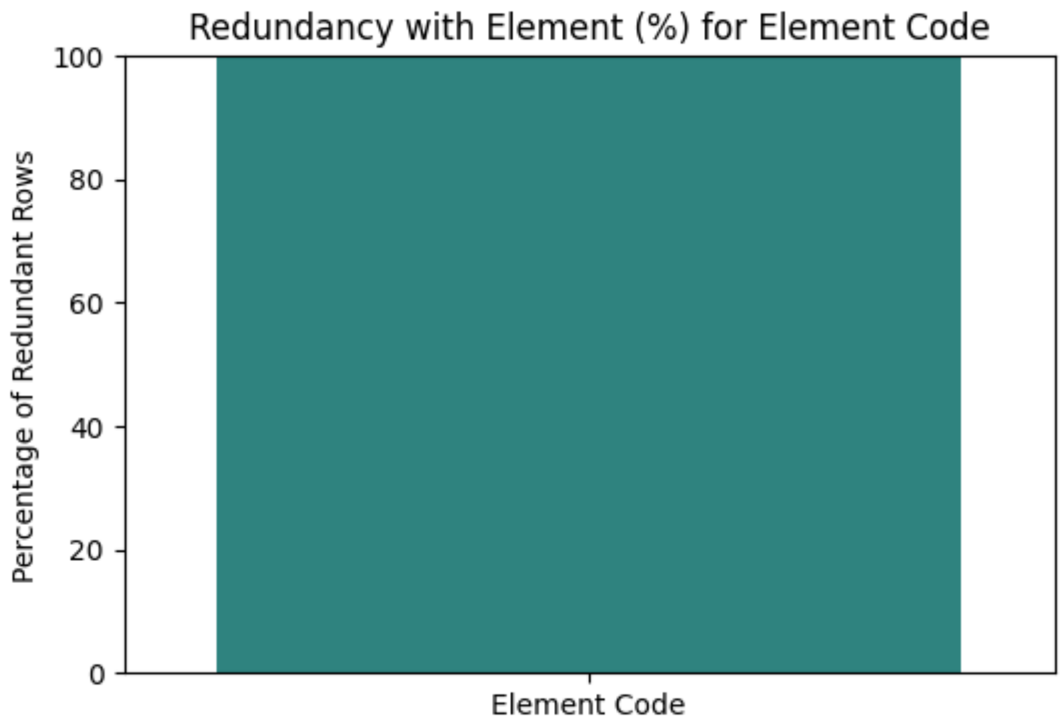

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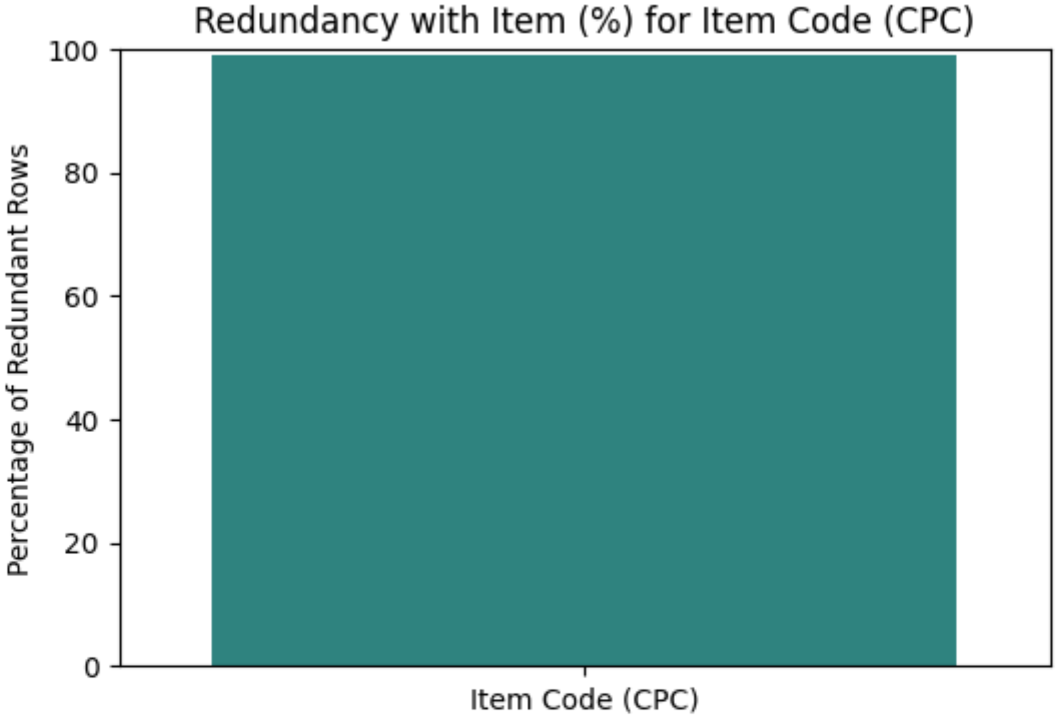


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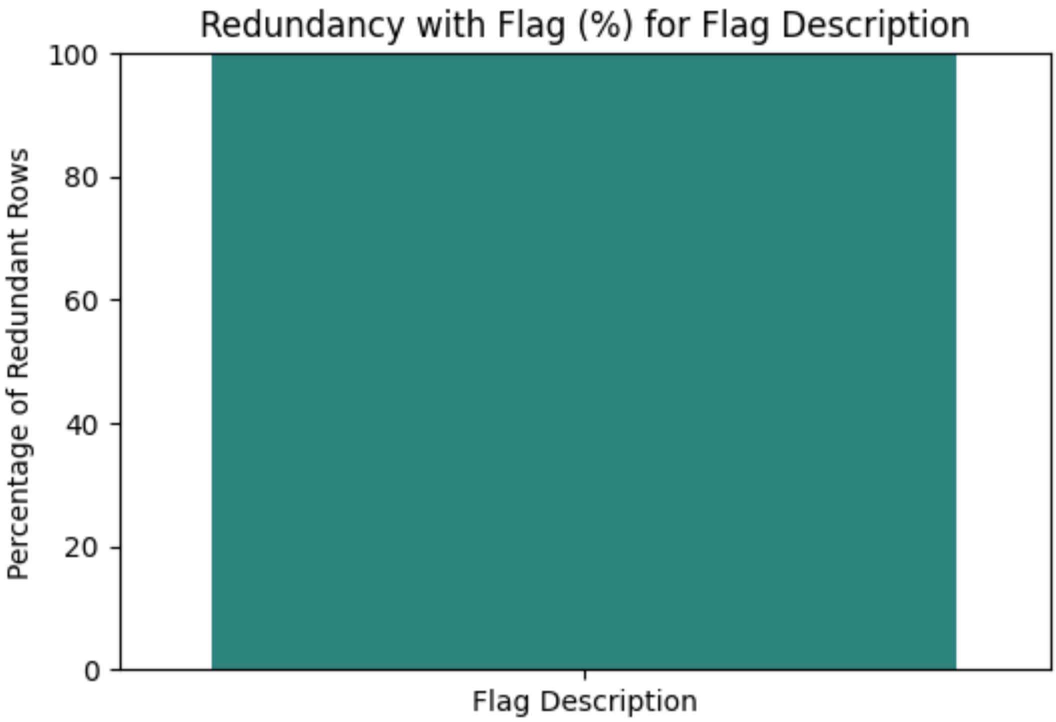


```
In [97]: df_dropped_irrelevant = df.drop(columns=['Domain Code', 'Domain', "Area",
```

```
In [98]: df_yeild = df_dropped_irrelevant[df_dropped_irrelevant['Element'] == "Yie
```

```
In [99]: final_df = df_yeild.drop("Element", axis=1)
```

One Hot Encoding Object Variables

Since object variable cannot be used by the selected machine learning model we will use One H Encoding

```
In [100… final_df = pd.get_dummies(final_df, columns = ["Item", "Unit", "Flag"])
```

Seperate Training and Target Variable

```
In [101… X = final_df.drop("Value", axis=1)
         y = final_df["Value"]
```

```
In [102… X
```

Out[102…

	Year	Item_Maize (corn)	Item_Other pulses n.e.c.	Item_Potatoes	Item_Rice	Item_Seed cotton, unginned	Item_Sorghum
0	1961	True	False	False	False	False	False
2	1962	True	False	False	False	False	False
4	1963	True	False	False	False	False	False
6	1964	True	False	False	False	False	False
8	1965	True	False	False	False	False	False
...	...	...	...	...	...	...	...
1105	2019	False	False	False	False	False	False
1107	2020	False	False	False	False	False	False
1109	2021	False	False	False	False	False	False
1111	2022	False	False	False	False	False	False
1113	2023	False	False	False	False	False	False

548 rows × 13 columns

In [103…

```
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score
```

In [104…

```
X_train, X_test, y_train, y_test = train_test_split(
    X, y,
    random_state=15,
    shuffle=True,
    train_size=0.8
)
```

In [105…

```
rf = RandomForestRegressor(
    n_estimators=100,       # number of trees
    random_state=15,        # for reproducibility
    n_jobs=-1               # use all CPU cores
)
```

In [106…

```
# 2. Train the model
rf.fit(X_train, y_train)
```

Out[106…

```
▾ RandomForestRegressor
RandomForestRegressor(n_jobs=-1, random_state=15)
```

In [107…

```python
# 3. Make predictions
y_pred = rf.predict(X_test)

# 4. Evaluate performance
mse = mean_squared_error(y_test, y_pred)
rmse = mse ** 0.5  # root mean squared error
r2 = r2_score(y_test, y_pred)

print("Random Forest Regressor Results:")
print(f"Mean Squared Error (MSE): {mse:.3f}")
print(f"Root Mean Squared Error (RMSE): {rmse:.3f}")
print(f"R² Score: {r2:.3f}")
```

```
Random Forest Regressor Results:
Mean Squared Error (MSE): 86861.603
Root Mean Squared Error (RMSE): 294.723
R² Score: 0.993
```