In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
sns.set_theme(color_codes=True)
```

In [2]:
```
df = pd.read_csv('Smart watch prices.csv')
df.head()
```

Out[2]:

	Brand	Model	Operating System	Connectivity	Display Type	Display Size (inches)	Resolution	Water Resistance (meters)	Battery Life (days)	Heart Rate Monitor
0	Apple	Watch Series 7	watchOS	Bluetooth, Wi-Fi, Cellular	Retina	1.90	396 x 484	50	18	Yes
1	Samsung	Galaxy Watch 4	Wear OS	Bluetooth, Wi-Fi, Cellular	AMOLED	1.40	450 x 450	50	40	Yes
2	Garmin	Venu 2	Garmin OS	Bluetooth, Wi-Fi	AMOLED	1.30	416 x 416	50	11	Yes
3	Fitbit	Versa 3	Fitbit OS	Bluetooth, Wi-Fi	AMOLED	1.58	336 x 336	50	6	Yes
4	Fossil	Gen 6	Wear OS	Bluetooth, Wi-Fi	AMOLED	1.28	416 x 416	30	24	Yes

Data Preprocessing Part 1

In [3]:
```
#Check ther number of unique value
df.select_dtypes(include='object').nunique()
```

Out[3]:
```
Brand                        42
Model                       137
Operating System             35
Connectivity                  5
Display Type                 27
Resolution                   36
Water Resistance (meters)     7
Battery Life (days)          30
Heart Rate Monitor            1
GPS                           2
NFC                           2
Price (USD)                  50
dtype: int64
```

In [4]:
```
df.shape
```

Out[4]:
```
(379, 13)
```

In [5]:
```
df.drop(columns='Model', inplace=True)
df.shape
```

Out[5]:
```
(379, 12)
```

Remove Dollar and Comma from Price (USD)

In [6]:
```
#remove '$' and comma from Price(USD) column
df['Price (USD)'] = df['Price (USD)'].str.replace(',', '').str.replace('$', '')

# Convert the Price(USD) column to numeric values
df['Price (USD)'] = pd.to_numeric(df['Price (USD)'])
df.head()
```

```
C:\Users\Michael\AppData\Local\Temp\ipykernel_20456\4168433824.py:2: FutureWarning:
The default value of regex will change from True to False in a future version. In ad
dition, single character regular expressions will *not* be treated as literal string
s when regex=True.
  df['Price (USD)'] = df['Price (USD)'].str.replace(',', '').str.replace('$', '')
```

Out[6]:

	Brand	Operating System	Connectivity	Display Type	Display Size (inches)	Resolution	Water Resistance (meters)	Battery Life (days)	Heart Rate Monitor	GPS
0	Apple	watchOS	Bluetooth, Wi-Fi, Cellular	Retina	1.90	396 x 484	50	18	Yes	Yes
1	Samsung	Wear OS	Bluetooth, Wi-Fi, Cellular	AMOLED	1.40	450 x 450	50	40	Yes	Yes
2	Garmin	Garmin OS	Bluetooth, Wi-Fi	AMOLED	1.30	416 x 416	50	11	Yes	Yes
3	Fitbit	Fitbit OS	Bluetooth, Wi-Fi	AMOLED	1.58	336 x 336	50	6	Yes	Yes
4	Fossil	Wear OS	Bluetooth, Wi-Fi	AMOLED	1.28	416 x 416	30	24	Yes	Yes

In [7]:
```
df.dtypes
```

Out[7]:
```
Brand                        object
Operating System             object
Connectivity                 object
Display Type                 object
Display Size (inches)       float64
Resolution                   object
Water Resistance (meters)    object
Battery Life (days)          object
Heart Rate Monitor           object
GPS                          object
NFC                          object
Price (USD)                 float64
dtype: object
```

Segment the Operating System

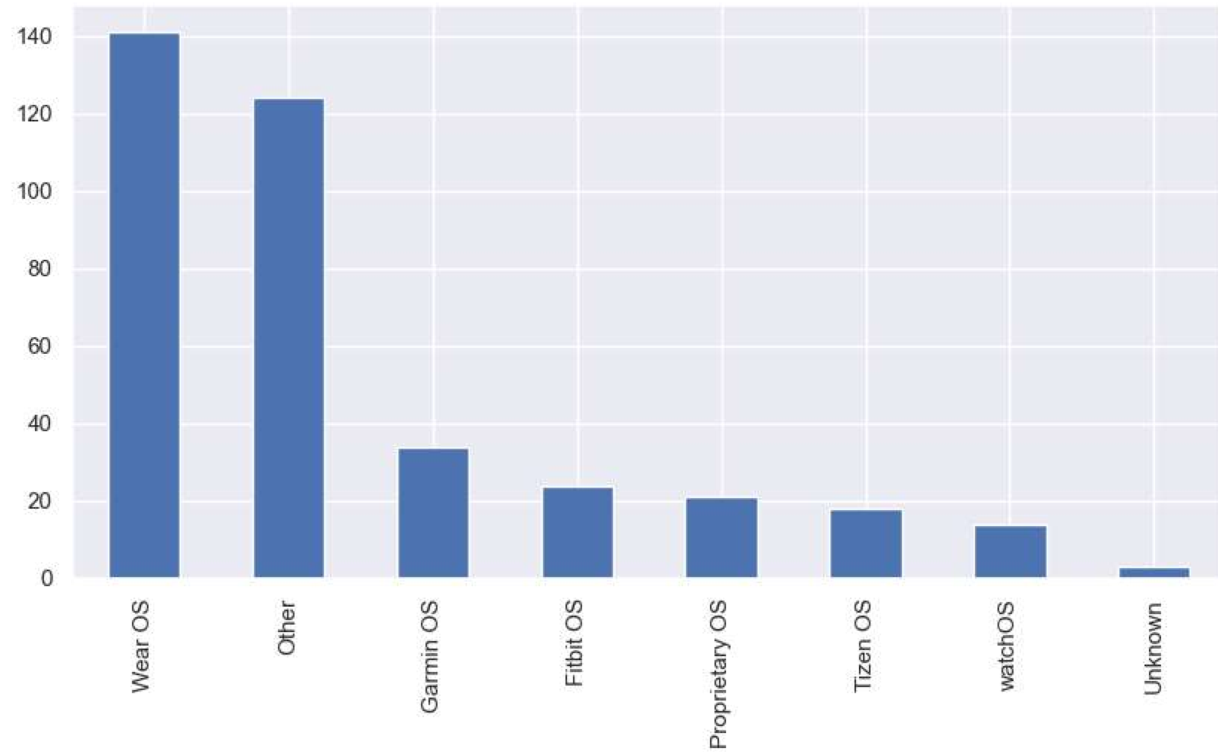
In [8]:
```
df['Operating System'].unique()
```

Out[8]:
```
array(['watchOS', 'Wear OS', 'Garmin OS', 'Fitbit OS', 'HarmonyOS',
       'ColorOS', 'Amazfit OS', nan, 'Withings OS', 'Polar OS',
       'Tizen OS', 'Hybrid OS', 'Lite OS', 'Tizen', 'Suunto OS',
       'Proprietary OS', 'Proprietary', 'LiteOS', 'Android Wear',
       'MIUI for Watch', 'Custom OS', 'Fossil OS', 'MIUI', 'RTOS',
       'MyKronoz OS', 'Nubia OS', 'Mi Wear OS', 'Zepp OS', 'Realme OS',
       'Matrix OS', 'Android OS', 'Casio OS', 'Skagen OS', 'Timex OS',
       'MIUI For Watch', 'Android'], dtype=object)
```

In [9]:
```
def segment_os(os):
    if pd.isnull(os):
        return 'Unknown'
    elif 'watchOS' in os:
        return 'watchOS'
    elif 'Wear OS' in os or 'Android Wear' in os:
        return 'Wear OS'
    elif 'Garmin' in os:
        return 'Garmin OS'
    elif 'Fitbit' in os:
        return 'Fitbit OS'
    elif 'Tizen' in os:
        return 'Tizen OS'
    elif 'Proprietary' in os:
        return 'Proprietary OS'
    else:
        return 'Other'

df['Operating System'] = df['Operating System'].apply(segment_os)
```

In [10]:
```
plt.figure(figsize=(10,5))
df['Operating System'].value_counts().plot(kind='bar')
```

Out[10]: <AxesSubplot:>



Segment the Display Type

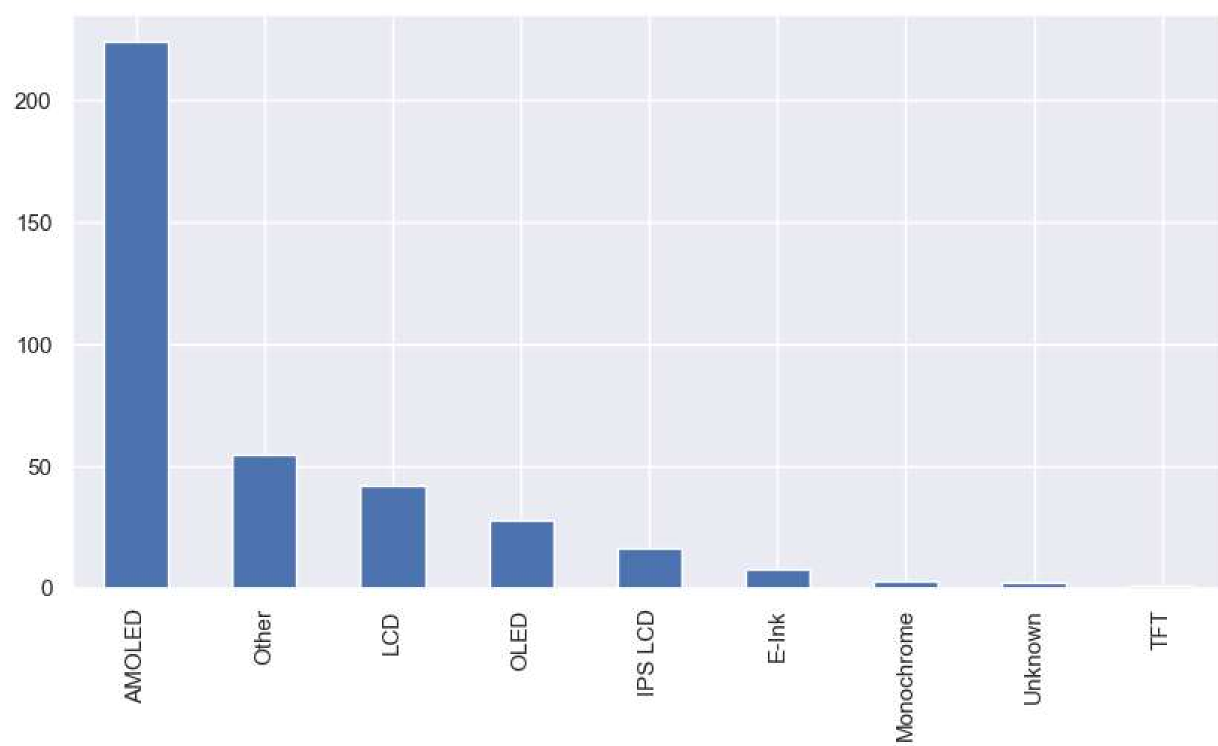
In [11]:
```
df['Display Type'].unique()
```

Out[11]:
```
array(['Retina', 'AMOLED', 'IPS LCD', nan, 'TFT LCD',
       'Memory-in-pixel (MIP)', 'Super AMOLED', 'LCD', 'Analog',
       'Transflective', 'OLED', 'Gorilla Glass', 'MIP', 'P-OLED',
       'transflective', 'PMOLED', 'TFT',
       'Sunlight-visible, transflective memory-in-pixel (MIP)', 'E-Ink',
       'E-ink', 'Sunlight-visible', 'Color Touch', 'IPS', 'Dual Layer',
       'TFT-LCD', 'STN LCD', 'Monochrome', 'Memory LCD'], dtype=object)
```

In [12]:
```
def segment_display_type(display_type):
    if pd.isnull(display_type):
        return 'Unknown'
    elif 'AMOLED' in display_type:
        return 'AMOLED'
    elif 'IPS LCD' in display_type or 'IPS' in display_type:
        return 'IPS LCD'
    elif 'LCD' in display_type:
        return 'LCD'
    elif 'OLED' in display_type:
        return 'OLED'
    elif 'TFT' in display_type:
        return 'TFT'
    elif 'E-Ink' in display_type or 'E-ink' in display_type:
        return 'E-Ink'
    elif 'PMOLED' in display_type:
        return 'PMOLED'
    elif 'STN LCD' in display_type:
        return 'STN LCD'
    elif 'Monochrome' in display_type:
        return 'Monochrome'
    elif 'Memory LCD' in display_type:
        return 'Memory LCD'
    else:
        return 'Other'

df['Display Type'] = df['Display Type'].apply(segment_display_type)
```

In [13]:
```
plt.figure(figsize=(10,5))
df['Display Type'].value_counts().plot(kind='bar')
```

Out[13]: <AxesSubplot:>



Remove Heart Rate Monitor because it only has 1 unique value

In [14]:
```
df.drop(columns='Heart Rate Monitor', inplace=True)
df.shape
```

Out[14]:
```
(379, 11)
```

Segment the Brand

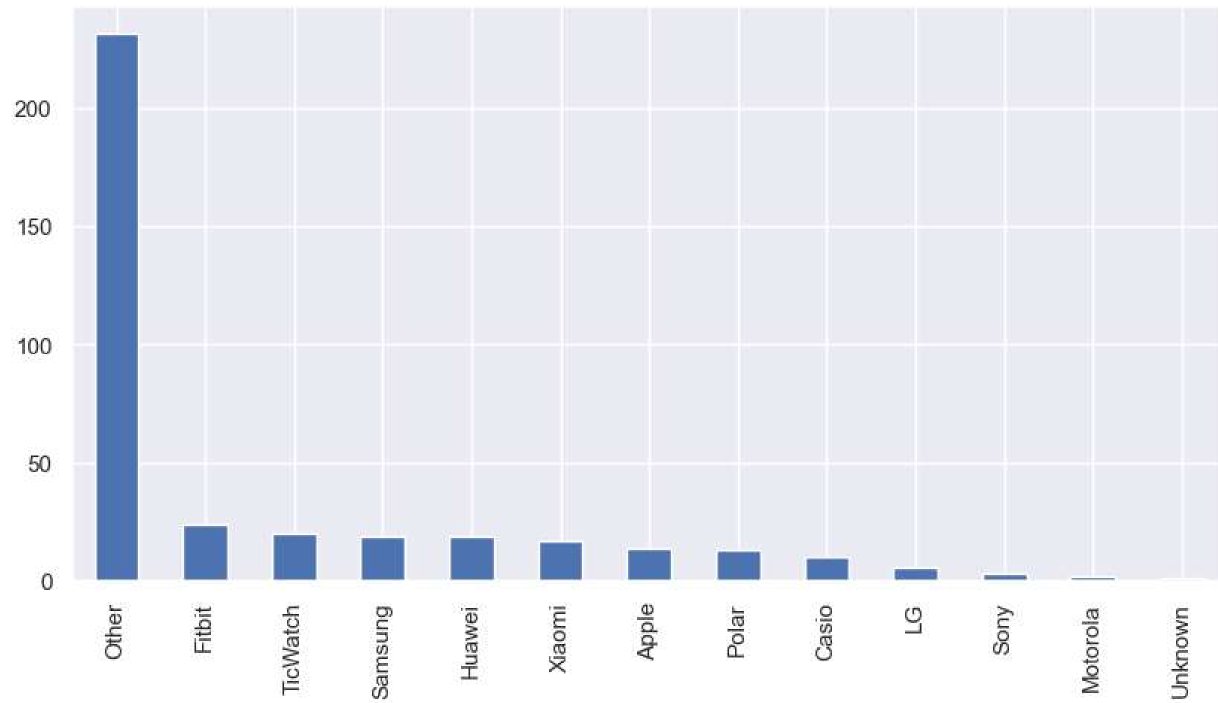
In [15]:
```
df['Brand'].unique()
```

Out[15]:
```
array(['Apple', 'Samsung', 'Garmin', 'Fitbit', 'Fossil', 'Huawei',
       'TicWatch', 'Oppo', 'Amazfit', 'Skagen', 'Withings', 'Timex',
       'Suunto', 'Mobvoi', 'Polar', 'Ticwatch', 'Xiaomi', 'Honor', 'LG',
       nan, 'Casio', 'OnePlus', 'Misfit', 'Moto', 'MyKronoz', 'Nubia',
       'Sony', 'Zepp', 'Realme', 'Matrix', 'Kate Spade', 'Diesel',
       'Michael Kors', 'Zeblaze', 'Kospet', 'Lemfo', 'TAG Heuer',
       'Montblanc', 'Asus', 'Emporio Armani', 'Polaroid', 'Motorola',
       'Nokia'], dtype=object)
```

In [16]:
```
def segment_brand(brand):
    if pd.isnull(brand):
        return 'Unknown'
    elif 'Apple' in brand:
        return 'Apple'
    elif 'Samsung' in brand:
        return 'Samsung'
    elif 'Fitbit' in brand:
        return 'Fitbit'
    elif 'Huawei' in brand:
        return 'Huawei'
    elif 'TicWatch' in brand or 'Ticwatch' in brand:
        return 'TicWatch'
    elif 'Polar' in brand:
        return 'Polar'
    elif 'Xiaomi' in brand:
        return 'Xiaomi'
    elif 'LG' in brand:
        return 'LG'
    elif 'Casio' in brand:
        return 'Casio'
    elif 'Moto' in brand or 'Motorola' in brand:
        return 'Motorola'
    elif 'Sony' in brand:
        return 'Sony'
    else:
        return 'Other'

df['Brand'] = df['Brand'].apply(segment_brand)
```

In [17]:
```
plt.figure(figsize=(10,5))
df['Brand'].value_counts().plot(kind='bar')
```

Out[17]: <AxesSubplot:>



Segment the Resolution

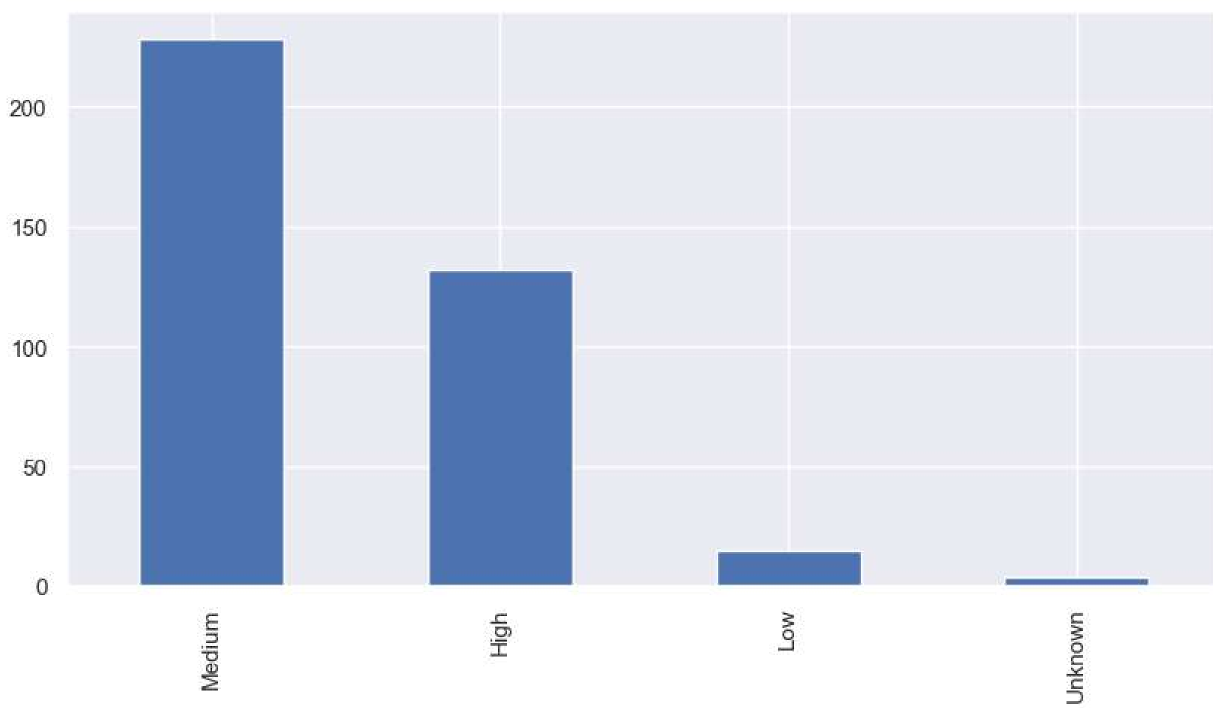
In [18]:
```
df.Resolution.unique()
```

Out[18]:
```
array(['396 x 484', '450 x 450', '416 x 416', '336 x 336', '466 x 466',
       '360 x 360', '372 x 430', '454 x 454', nan, '240 x 240',
       '390 x 390', '394 x 324', '240 x 201', '368 x 448', '400 x 400',
       '324 x 394', '320 x 320', '348 x 442', '402 x 476', '480 x 480',
       '176 x 176', '300 x 300', '200 x 200', '280 x 280', '128 x 128',
       '240 x 198', '280 x 456', '328 x 328', '960 x 192', '348 x 250',
       '320 x 300', '320 x 302', '228 x 172', '160 x 160', '260 x 260',
       '126 x 36', '326 x 326'], dtype=object)
```

In [19]:
```
def segment_resolution(resolution):
    if pd.isnull(resolution):
        return 'Unknown'
    res = resolution.split(' x ')
    width = int(res[0])
    height = int(res[1])
    if width < 200 or height < 200:
        return 'Low'
    elif width < 400 or height < 400:
        return 'Medium'
    elif width < 800 or height < 800:
        return 'High'
    else:
        return 'Very high'

df['Resolution'] = df['Resolution'].apply(segment_resolution)
```

In [20]:
```
plt.figure(figsize=(10,5))
df['Resolution'].value_counts().plot(kind='bar')
```

Out[20]: <AxesSubplot:>



Segment Battery Life Days

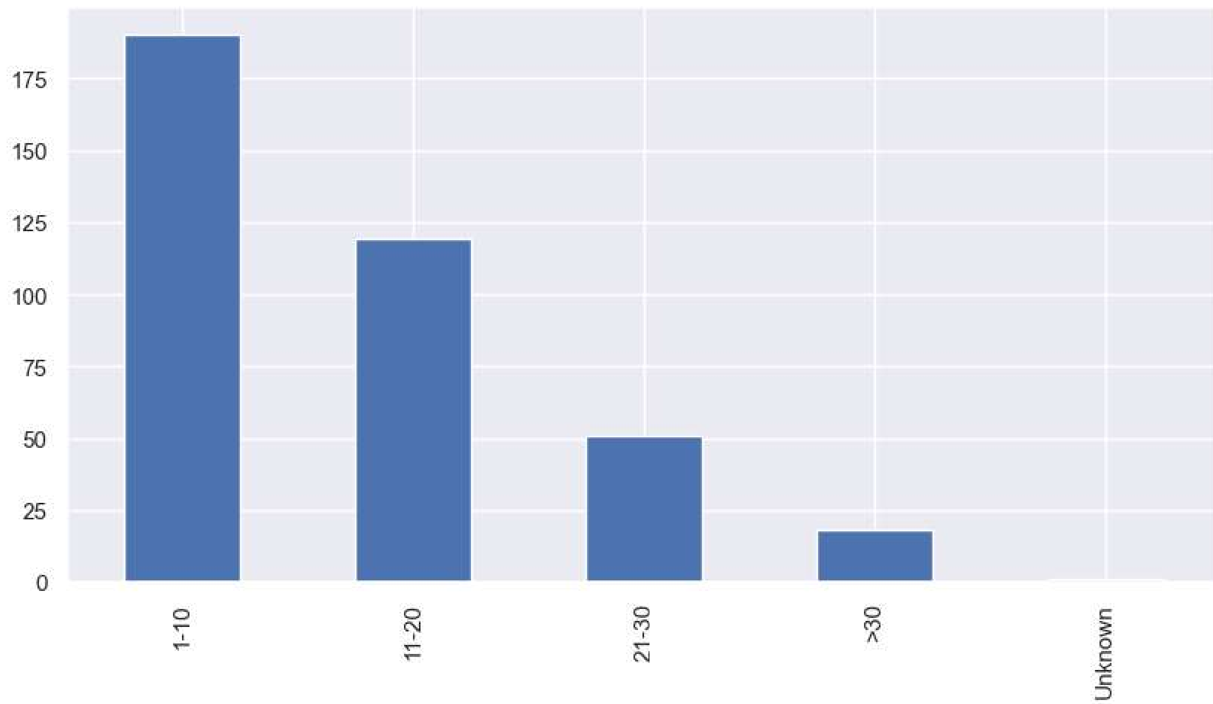
In [21]:
```
df['Battery Life (days)'].unique()
```

Out[21]:
```
array(['18', '40', '11', '6', '24', '14', '2', '4', '12', '30', '3', '45',
       '5', '10', '48', '7', '16', '9', '25', '72', '60', '56', nan, '70',
       '1', '48 hours', '15', 'Unlimited', '1.5', '20', '8'], dtype=object)
```

In [22]:
```
def segment_battery_life(battery_life):
    if pd.isnull(battery_life):
        return 'Unknown'
    elif battery_life == '48 hours':
        return '1-10'
    elif battery_life == '1.5':
        return '1-10'
    elif battery_life == 'Unlimited':
        return '>30'
    else:
        try:
            days = int(battery_life)
            if days >= 1 and days <= 10:
                return '1-10'
            elif days >= 11 and days <= 20:
                return '11-20'
            elif days >= 21 and days <= 30:
                return '21-30'
            else:
                return '>30'
        except ValueError:
            return 'Unknown'

df['Battery Life (days)'] = df['Battery Life (days)'].apply(segment_battery_life)
```

In [23]:
```
plt.figure(figsize=(10,5))
df['Battery Life (days)'].value_counts().plot(kind='bar')
```

Out[23]: <AxesSubplot:>



Segment Water Resistance (meters)

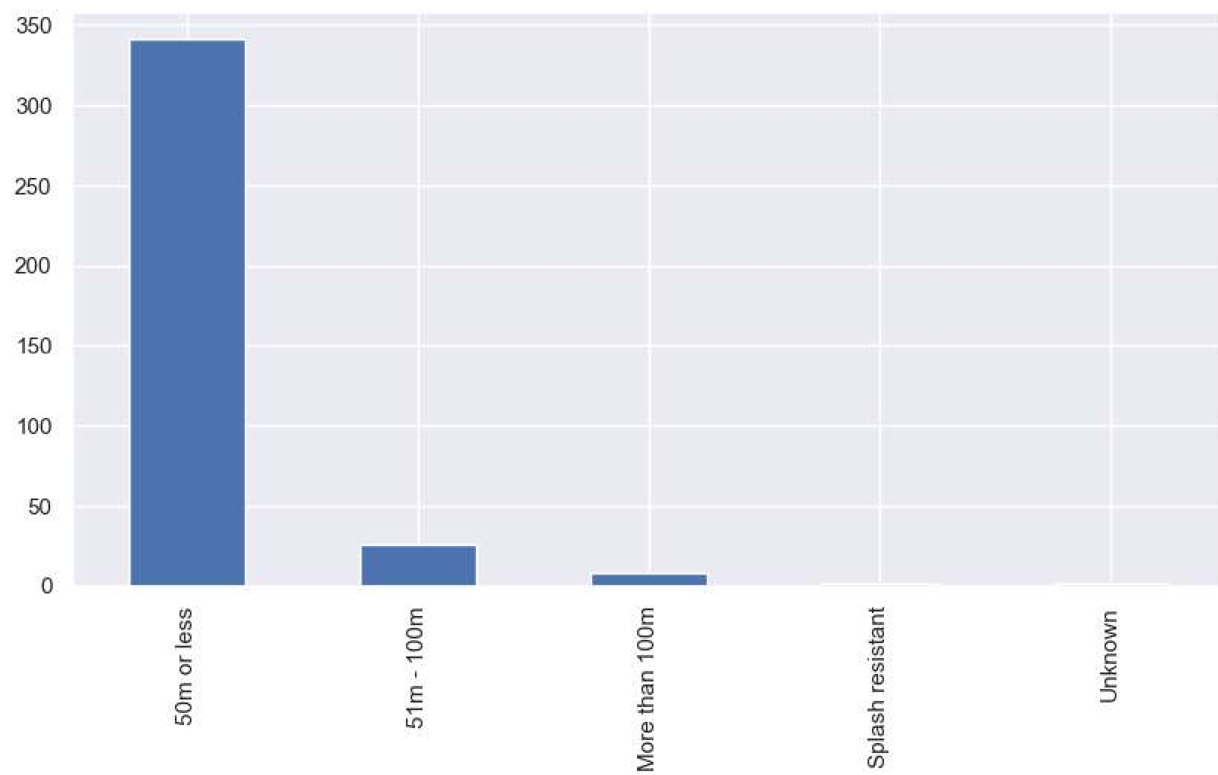
In [24]:
```
df['Water Resistance (meters)'].unique()
```

Out[24]:
```
array(['50', '30', '100', '1.5', nan, 'Not specified', '200', '10'],
      dtype=object)
```

In [25]:
```
def segment_water_resistance(water_resistance):
    if pd.isnull(water_resistance) or water_resistance == 'Not specified':
        return 'Unknown'
    elif water_resistance == '1.5':
        return 'Splash resistant'
    else:
        depth = int(water_resistance)
        if depth >= 0 and depth <= 50:
            return '50m or less'
        elif depth > 50 and depth <= 100:
            return '51m - 100m'
        else:
            return 'More than 100m'


df['Water Resistance (meters)'] = df['Water Resistance (meters)'].apply(segment_water_
```

In [26]:
```
plt.figure(figsize=(10,5))
df['Water Resistance (meters)'].value_counts().plot(kind='bar')
```

Out[26]: <AxesSubplot:>

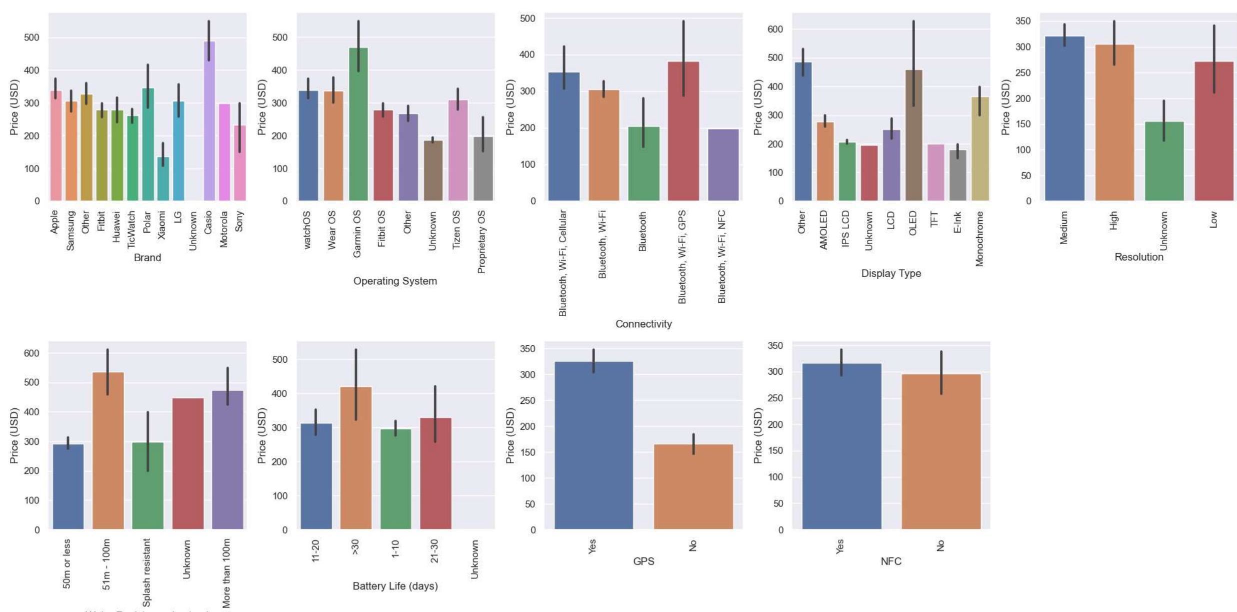


Exploratory Data Analysis

In [27]:
```
#Check ther number of unique value
df.select_dtypes(include='object').nunique()
```

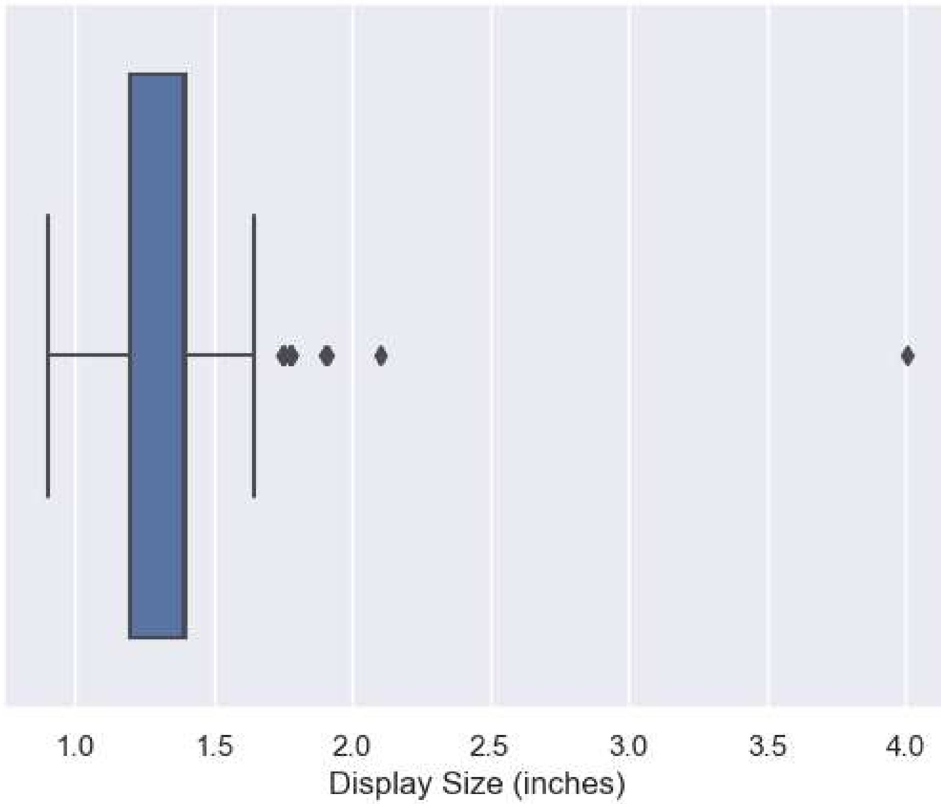
Out[27]:
```
Brand                       13
Operating System             8
Connectivity                 5
Display Type                 9
Resolution                   4
Water Resistance (meters)    5
Battery Life (days)          5
GPS                          2
NFC                          2
dtype: int64
```

In [28]:
```
# list of categorical variables to plot
cat_vars = ['Brand', 'Operating System', 'Connectivity', 'Display Type', 'Resolution'
            'Water Resistance (meters)', 'Battery Life (days)', 'GPS', 'NFC']

# create figure with subplots
fig, axs = plt.subplots(nrows=2, ncols=5, figsize=(20, 10))
axs = axs.flatten()

# create barplot for each categorical variable
for i, var in enumerate(cat_vars):
    sns.barplot(x=var, y='Price (USD)', data=df, ax=axs[i])
    axs[i].set_xticklabels(axs[i].get_xticklabels(), rotation=90)

# adjust spacing between subplots
fig.tight_layout()

# remove the tenth subplot
fig.delaxes(axs[9])

# show plot
plt.show()
```



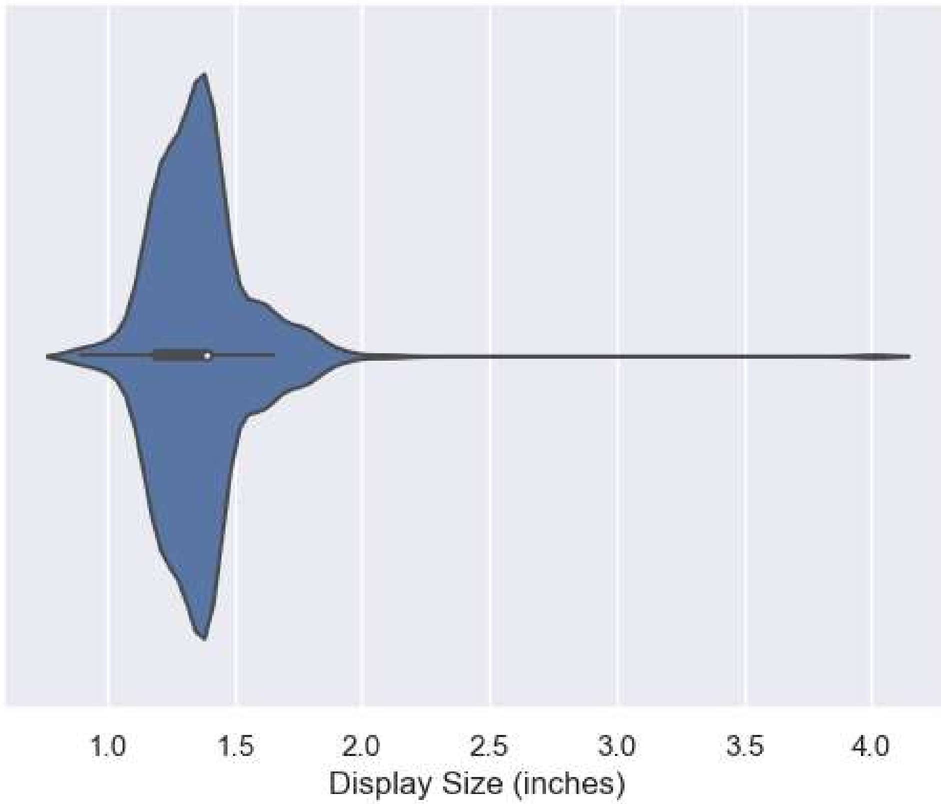
In [29]:
```
sns.boxplot(x=df["Display Size (inches)"])
```

Out[29]: <AxesSubplot:xlabel='Display Size (inches)'>



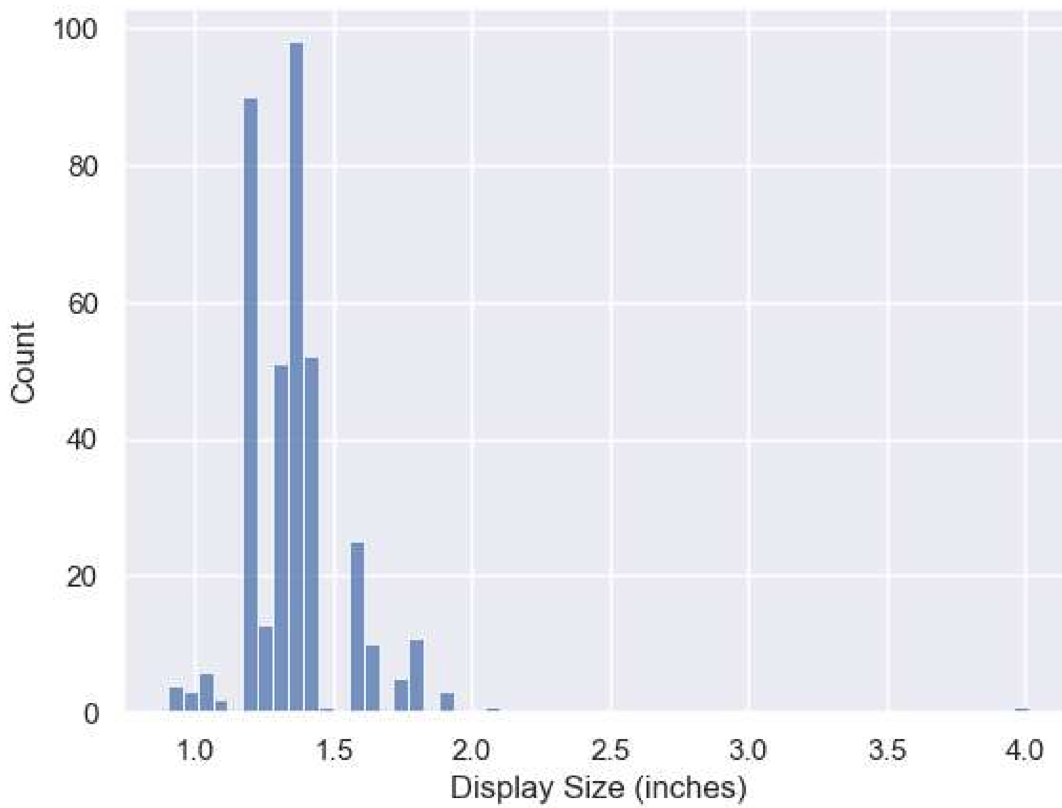
In [30]:
```
sns.violinplot(x=df["Display Size (inches)"])
```

Out[30]: <AxesSubplot:xlabel='Display Size (inches)'>



In [31]:
```
sns.histplot(data=df, x="Display Size (inches)")
```

Out[31]: <AxesSubplot:xlabel='Display Size (inches)', ylabel='Count'>



Data Preprocessing Part 2

In [32]:
```
#Check the missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[32]:
```
Display Size (inches)    0.791557
Connectivity             0.263852
GPS                      0.263852
NFC                      0.263852
Price (USD)              0.263852
dtype: float64
```

In [33]:
```
df.dropna(inplace=True)
df.shape
```

Out[33]: (376, 11)

In [34]:
```
#Check the missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[34]: Series([], dtype: float64)

Label Encoding for Object datatypes

In [35]:
```
# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Print the column name and the unique values
    print(f"{col}: {df[col].unique()}")
```

```
Brand: ['Apple' 'Samsung' 'Other' 'Fitbit' 'Huawei' 'TicWatch' 'Polar' 'Xiaomi'
 'LG' 'Casio' 'Motorola' 'Sony']
Operating System: ['watchOS' 'Wear OS' 'Garmin OS' 'Fitbit OS' 'Other' 'Unknown' 'Ti
zen OS'
 'Proprietary OS']
Connectivity: ['Bluetooth, Wi-Fi, Cellular' 'Bluetooth, Wi-Fi' 'Bluetooth'
 'Bluetooth, Wi-Fi, GPS' 'Bluetooth, Wi-Fi, NFC']
Display Type: ['Other' 'AMOLED' 'IPS LCD' 'LCD' 'OLED' 'TFT' 'E-Ink' 'Monochrome']
Resolution: ['Medium' 'High' 'Low' 'Unknown']
Water Resistance (meters): ['50m or less' '51m - 100m' 'Splash resistant' 'Unknown'
'More than 100m']
Battery Life (days): ['11-20' '>30' '1-10' '21-30']
GPS: ['Yes' 'No']
NFC: ['Yes' 'No']
```

In [36]:
```
from sklearn import preprocessing

# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Initialize a LabelEncoder object
    label_encoder = preprocessing.LabelEncoder()

    # Fit the encoder to the unique values in the column
    label_encoder.fit(df[col].unique())

    # Transform the column using the encoder
    df[col] = label_encoder.transform(df[col])

    # Print the column name and the unique encoded values
    print(f"{col}: {df[col].unique()}")
```

```
Brand: [ 0  8  6  2  3 10  7 11  4  1  5  9]
Operating System: [7 6 1 0 2 5 4 3]
Connectivity: [2 1 0 3 4]
Display Type: [6 0 2 3 5 7 1 4]
Resolution: [2 0 1 3]
Water Resistance (meters): [0 1 3 4 2]
Battery Life (days): [1 3 0 2]
GPS: [1 0]
NFC: [1 0]
```

Remove Outliers using Z-Score

In [37]:
```
from scipy import stats

# define a function to remove outliers using z-score for only selected numerical colur
def remove_outliers(df, cols, threshold=3):
    # loop over each selected column
    for col in cols:
        # calculate z-score for each data point in selected column
        z = np.abs(stats.zscore(df[col]))
        # remove rows with z-score greater than threshold in selected column
        df = df[(z < threshold) | (df[col].isnull())]
    return df
```

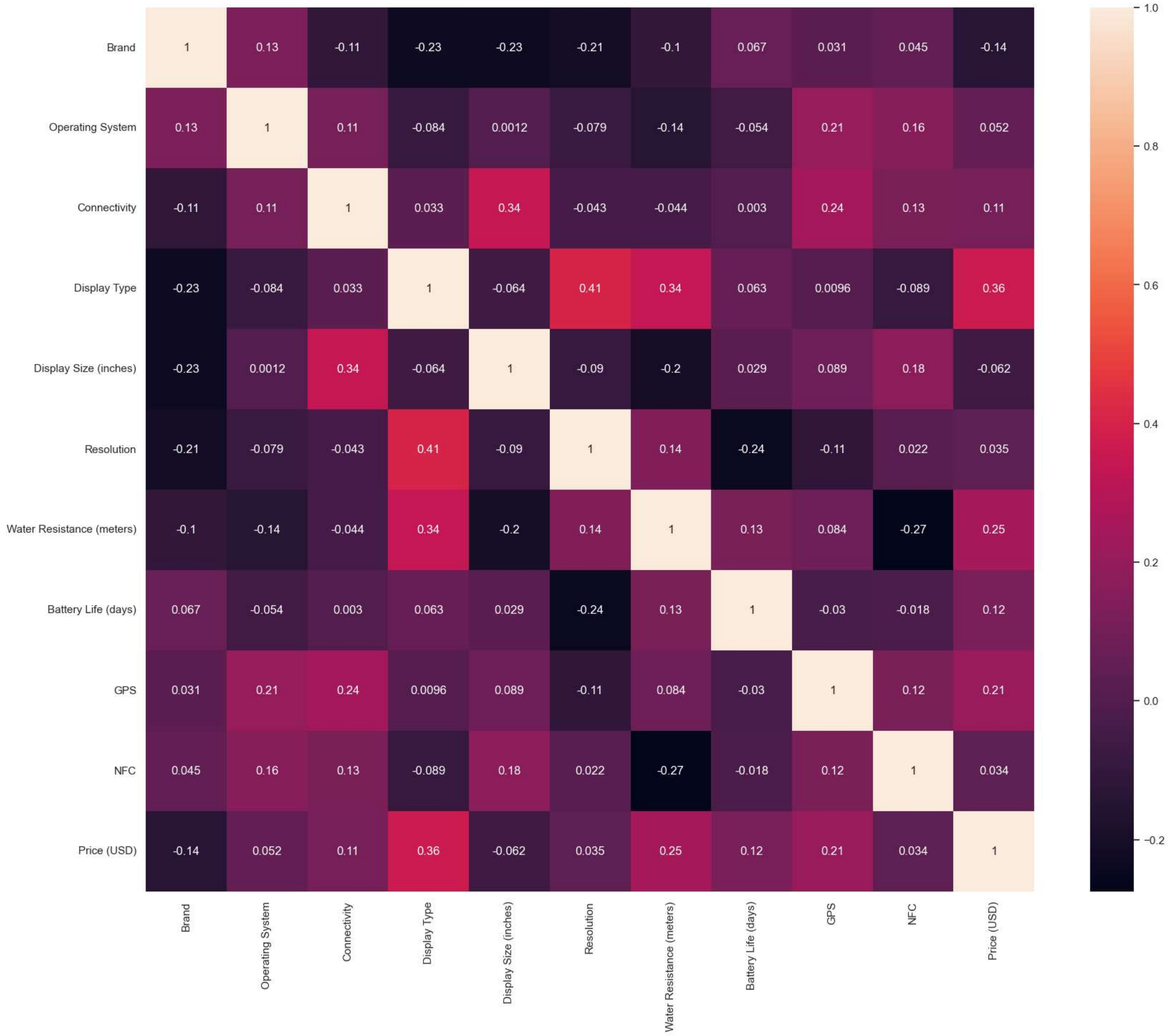
In [38]:
```
selected_cols = ['Display Size (inches)']
df_clean = remove_outliers(df, selected_cols)
df_clean.shape
```

Out[38]: (374, 11)

Correlation Heatmap

In [39]:
```
#Correlation Heatmap
plt.figure(figsize=(20, 16))
sns.heatmap(df_clean.corr(), fmt='.2g', annot=True)
```

Out[39]: <AxesSubplot:>



Train Test Split

In [40]:
```
X = df_clean.drop('Price (USD)', axis=1)
y = df_clean['Price (USD)']
```

In [41]:
```
#test size 20% and train size 80%
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.2,random_state=0
```

Decision Tree Regressor

In [42]:
```
from sklearn.tree import DecisionTreeRegressor
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import load_boston


# Create a DecisionTreeRegressor object
dtree = DecisionTreeRegressor()

# Define the hyperparameters to tune and their values
param_grid = {
    'max_depth': [2, 4, 6, 8],
    'min_samples_split': [2, 4, 6, 8],
    'min_samples_leaf': [1, 2, 3, 4],
    'max_features': ['auto', 'sqrt', 'log2']
}

# Create a GridSearchCV object
grid_search = GridSearchCV(dtree, param_grid, cv=5, scoring='neg_mean_squared_error')

# Fit the GridSearchCV object to the data
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print(grid_search.best_params_)
```

```
{'max_depth': 6, 'max_features': 'auto', 'min_samples_leaf': 1, 'min_samples_split':
6}
```

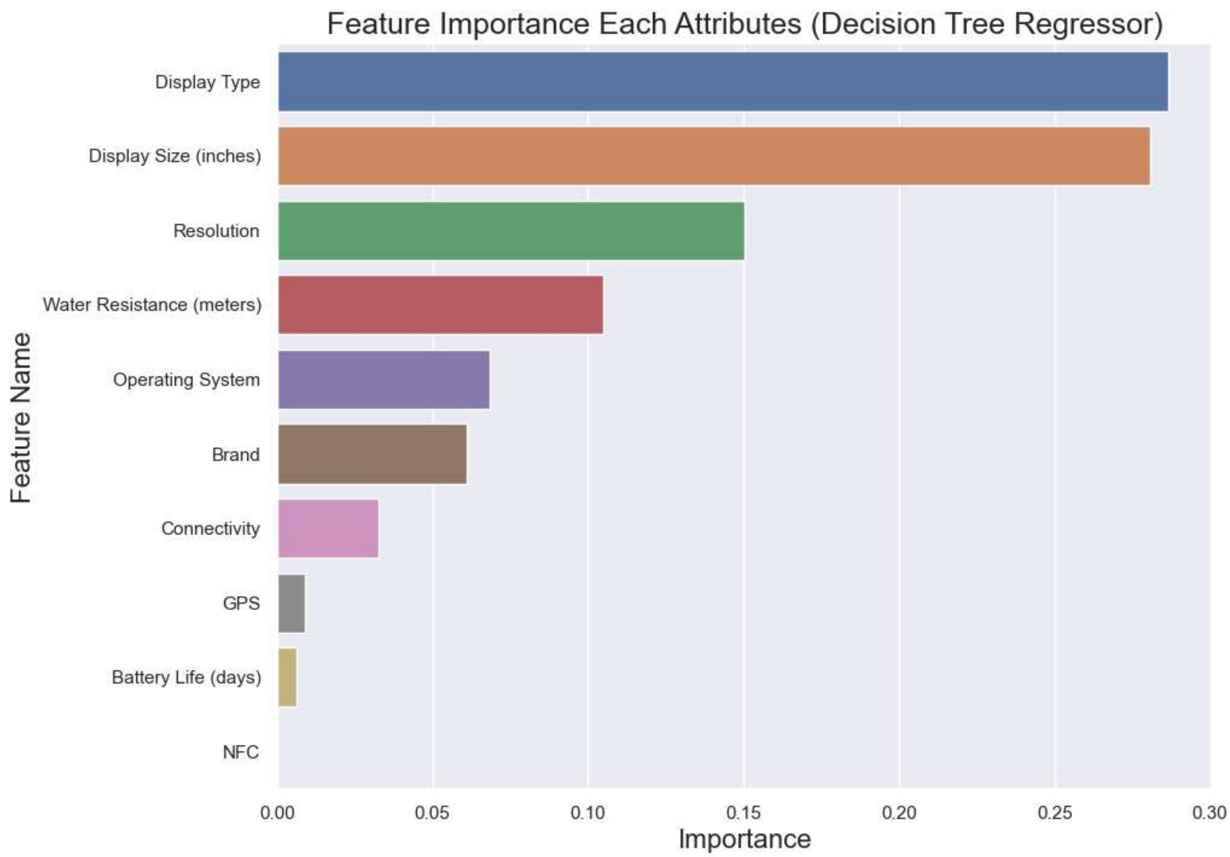
In [43]:
```
from sklearn.tree import DecisionTreeRegressor
dtree = DecisionTreeRegressor(random_state=0, max_depth=6, max_features='auto', min_sa
dtree.fit(X_train, y_train)
```

Out[43]:
```
DecisionTreeRegressor(max_depth=6, max_features='auto', min_samples_split=6,
                      random_state=0)
```

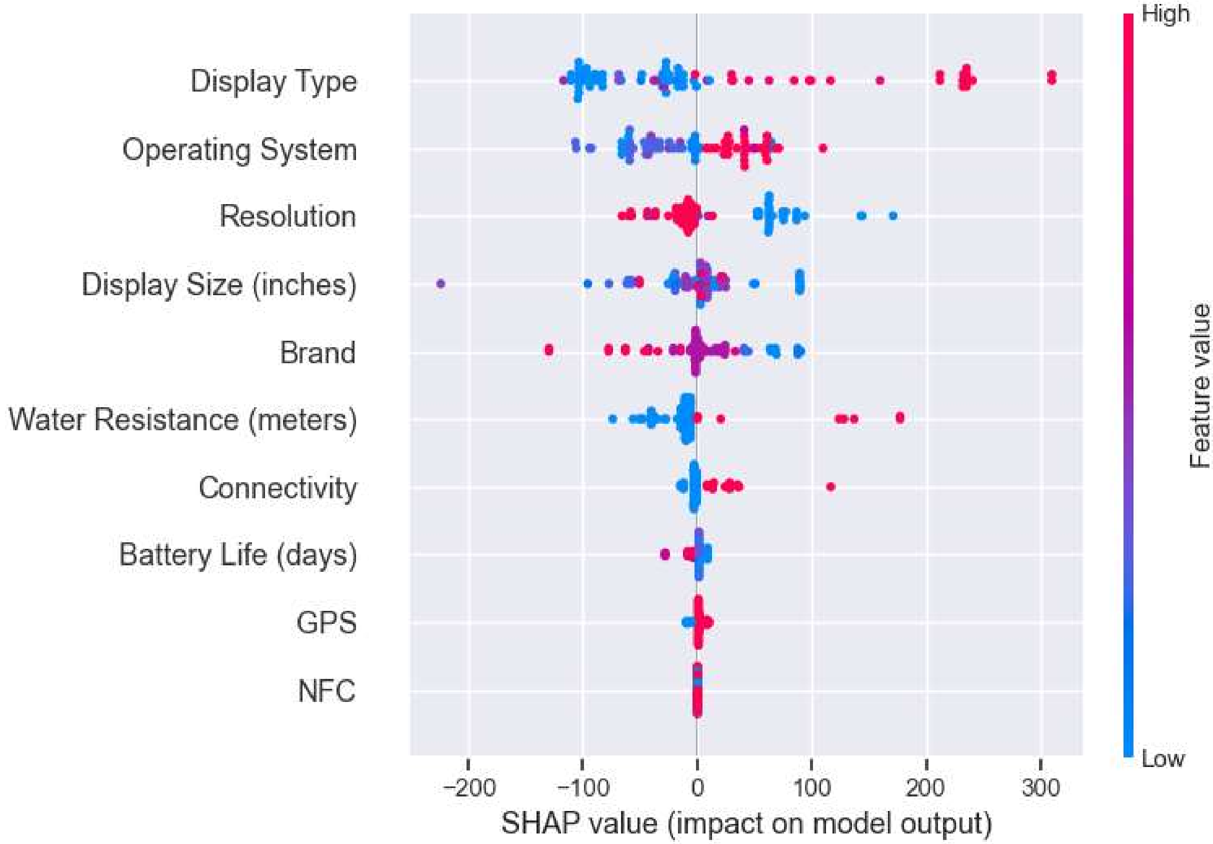
In [44]:
```
from sklearn import metrics
import math
y_pred = dtree.predict(X_test)
mae = metrics.mean_absolute_error(y_test, y_pred)
mse = metrics.mean_squared_error(y_test, y_pred)
r2 = metrics.r2_score(y_test, y_pred)
rmse = math.sqrt(mse)

print('MAE is {}'.format(mae))
print('MSE is {}'.format(mse))
print('R2 score is {}'.format(r2))
print('RMSE score is {}'.format(rmse))
```

```
MAE is 54.29975370674141
MSE is 7938.312275354595
R2 score is 0.6889144275851471
RMSE score is 89.09720688862583
```

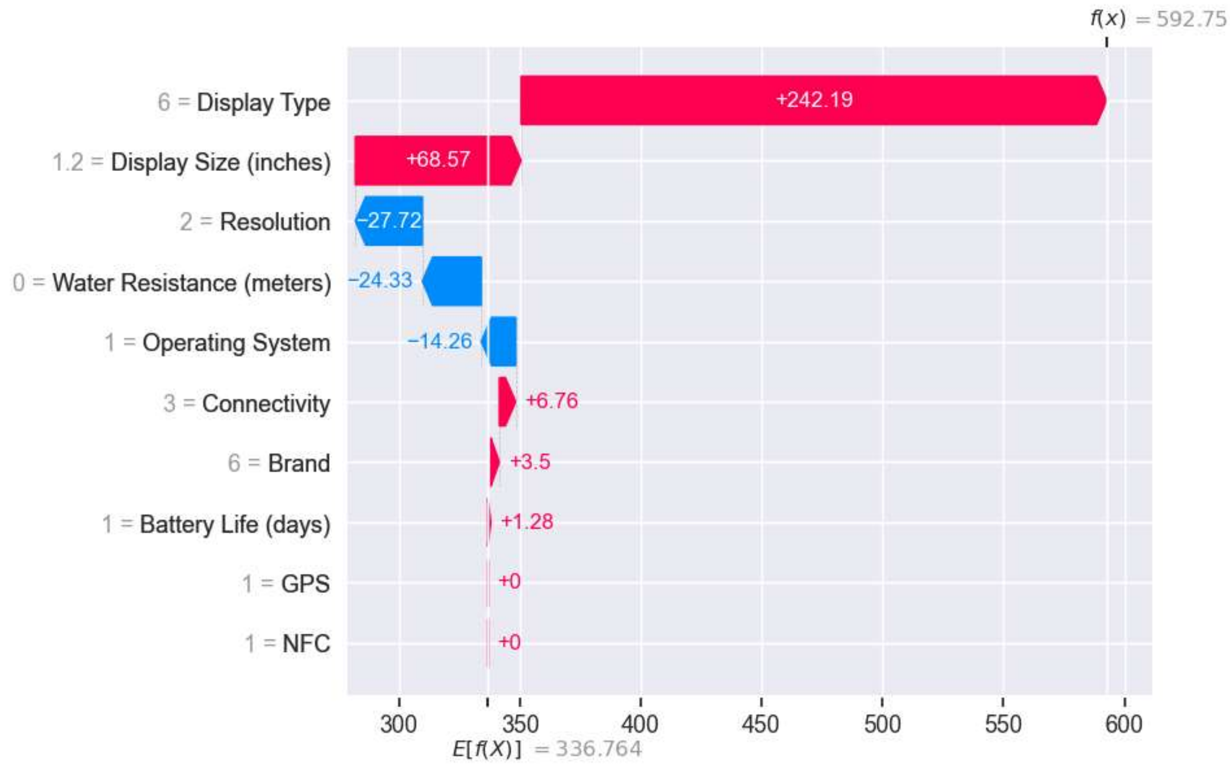
In [45]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": dtree.feature_importances_
})
fi = imp_df.sort_values(by="Importance", ascending=False)

fi2 = fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2, x='Importance', y='Feature Name')
plt.title('Feature Importance Each Attributes (Decision Tree Regressor)', fontsize=18
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```



In [46]:
```
import shap
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```



In [47]:
```
explainer = shap.Explainer(dtree, X_test)
shap_values = explainer(X_test)
shap.plots.waterfall(shap_values[0])
```



Random Forest Regressor

In [48]:
```
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV

# Create a Random Forest Regressor object
rf = RandomForestRegressor()

# Define the hyperparameter grid
param_grid = {
    'max_depth': [3, 5, 7, 9],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
    'max_features': ['auto', 'sqrt']
}

# Create a GridSearchCV object
grid_search = GridSearchCV(rf, param_grid, cv=5, scoring='r2')

# Fit the GridSearchCV object to the training data
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print("Best hyperparameters: ", grid_search.best_params_)
```

```
Best hyperparameters:  {'max_depth': 7, 'max_features': 'sqrt', 'min_samples_leaf':
2, 'min_samples_split': 5}
```

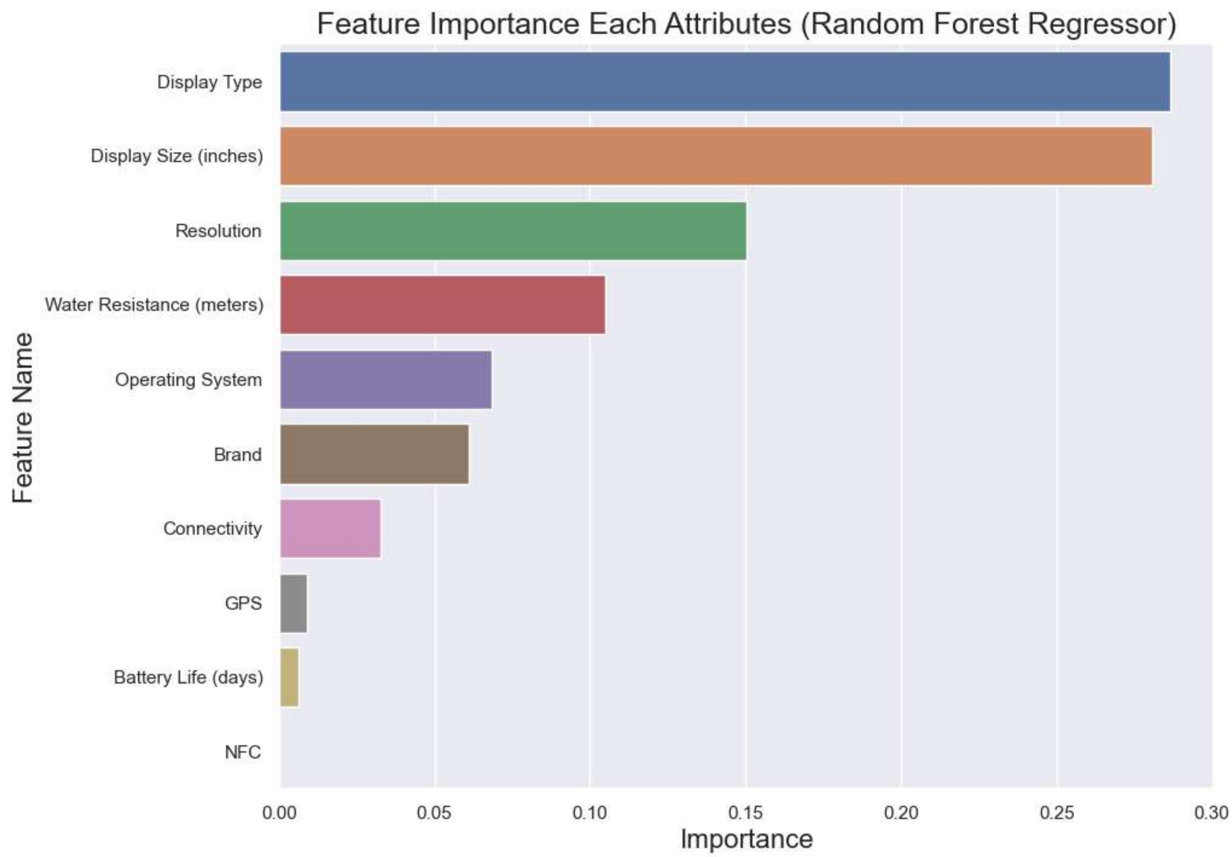
In [49]:
```
from sklearn.ensemble import RandomForestRegressor
rf = RandomForestRegressor(random_state=0, max_depth=7, min_samples_split=5, min_samp
                           max_features='sqrt')
rf.fit(X_train, y_train)
```

Out[49]:
```
RandomForestRegressor(max_depth=7, max_features='sqrt', min_samples_leaf=2,
                      min_samples_split=5, random_state=0)
```

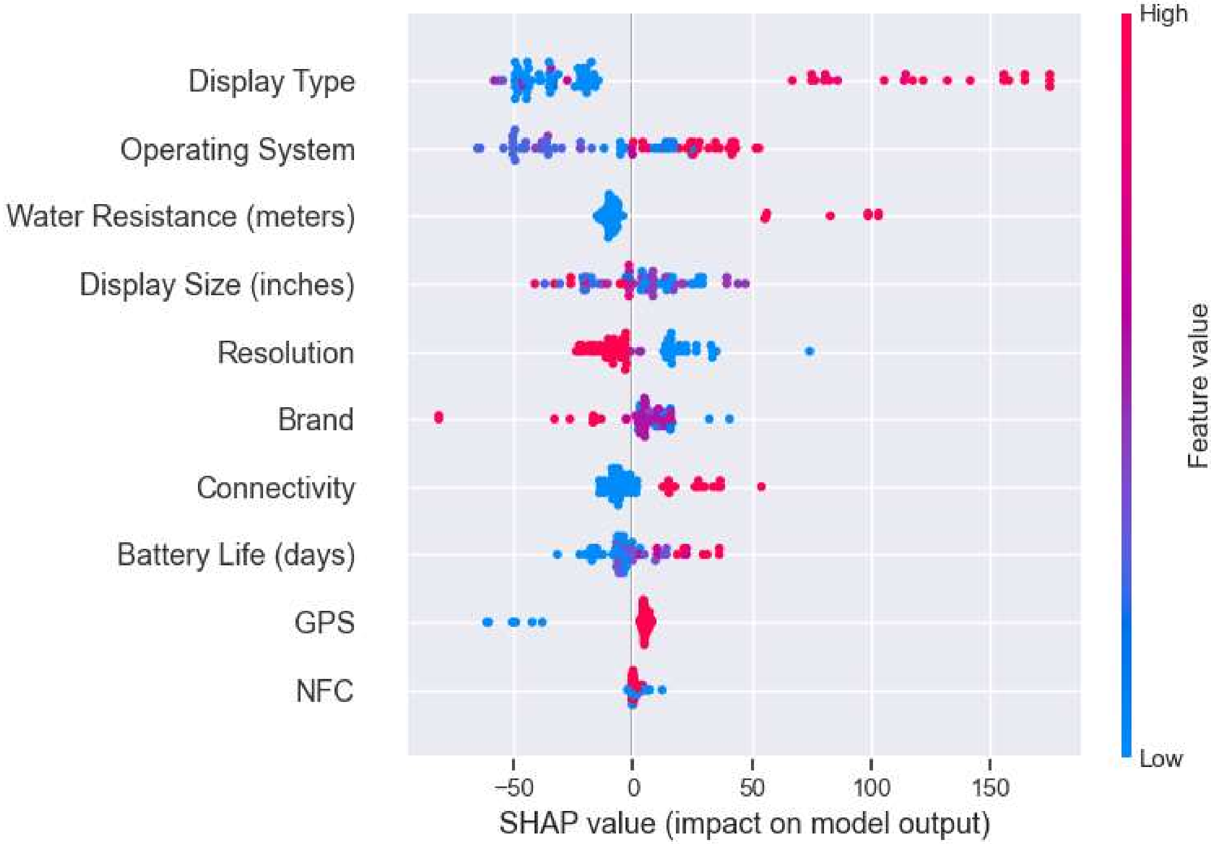
In [50]:
```
from sklearn import metrics
from sklearn.metrics import mean_absolute_percentage_error
import math
y_pred = rf.predict(X_test)
mae = metrics.mean_absolute_error(y_test, y_pred)
mape = mean_absolute_percentage_error(y_test, y_pred)
mse = metrics.mean_squared_error(y_test, y_pred)
r2 = metrics.r2_score(y_test, y_pred)
rmse = math.sqrt(mse)

print('MAE is {}'.format(mae))
print('MAPE is {}'.format(mape))
print('MSE is {}'.format(mse))
print('R2 score is {}'.format(r2))
print('RMSE score is {}'.format(rmse))
```

```
MAE is 63.55151926631857
MAPE is 0.27945164090811486
MSE is 6977.872978751223
R2 score is 0.7265520006598636
RMSE score is 83.5336637455297
```

In [51]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": dtree.feature_importances_
})
fi = imp_df.sort_values(by="Importance", ascending=False)

fi2 = fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2, x='Importance', y='Feature Name')
plt.title('Feature Importance Each Attributes (Random Forest Regressor)', fontsize=18
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```



In [52]:
```
import shap
explainer = shap.TreeExplainer(rf)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```



In [53]:
```
explainer = shap.Explainer(rf, X_test, check_additivity=False)
shap_values = explainer(X_test, check_additivity=False)
shap.plots.waterfall(shap_values[0])
```