```python
import pandas as pd

# Load datasets
crop_df = pd.read_csv("crop_production_cleaned.csv")
rain_df = pd.read_csv("rainfall_data_cleaned.csv")

# Display clean previews
print("CROP DATASET OVERVIEW\n")
display(crop_df.head())

print("\nRAINFALL DATASET OVERVIEW\n")
display(rain_df.head())
```

```
CROP DATASET OVERVIEW


                          state  district  year      season  \
0  Andaman and Nicobar Islands  Nicobars  2000      Kharif
1  Andaman and Nicobar Islands  Nicobars  2000      Kharif
2  Andaman and Nicobar Islands  Nicobars  2000      Kharif
3  Andaman and Nicobar Islands  Nicobars  2000  Whole Year
4  Andaman and Nicobar Islands  Nicobars  2000  Whole Year

                 crop    area  production  Unnamed: 7
0            Arecanut  1254.0      2000.0         NaN
1  Other Kharifpulses     2.0         1.0         NaN
2                Rice   102.0       321.0         NaN
3              Banana   176.0       641.0         NaN
4           Cashewnut   720.0       165.0         NaN


RAINFALL DATASET OVERVIEW


                  subdivision  year   jan    feb   mar    apr    may
jun  \
0  Andaman & Nicobar Islands  1901  49.2   87.1  29.2    2.3  528.8
517.5
1  Andaman & Nicobar Islands  1902   0.0  159.8  12.2    0.0  446.1
537.1
2  Andaman & Nicobar Islands  1903  12.7  144.0   0.0    1.0  235.1
479.9
3  Andaman & Nicobar Islands  1904   9.4   14.7   0.0  202.4  304.5
495.1
4  Andaman & Nicobar Islands  1905   1.3    0.0   3.3   26.9  279.5
628.7

     jul    aug    sep    oct    nov    dec  annual    jjas
0  365.1  481.1  332.6  388.5  558.2   33.6  3373.2  1696.3
1  228.9  753.7  666.2  197.2  359.0  160.5  3520.7  2185.9
2  728.4  326.7  339.0  181.2  284.4  225.0  2957.4  1874.0
```

```
3  502.0  160.1  820.4  222.2  308.7   40.1  3079.6  1977.6
4  368.7  330.5  297.0  260.7   25.4  344.7  2566.7  1624.9

# --- CROP DATASET OVERVIEW ---
print("CROP DATASET INFO:")
crop_df.info()
print("\nBasic Stats:")
print(crop_df.describe(include='all').transpose())

print("\nMissing Values:")
print(crop_df.isnull().sum())

print("\nUnique entries per column:")
crop_df.nunique()

CROP DATASET INFO:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 8 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   state       1000 non-null   object
 1   district    1000 non-null   object
 2   year        1000 non-null   int64
 3   season      1000 non-null   object
 4   crop        1000 non-null   object
 5   area        1000 non-null   float64
 6   production  1000 non-null   float64
 7   Unnamed: 7  0 non-null      float64
dtypes: float64(3), int64(1), object(4)
memory usage: 62.6+ KB

Basic Stats:
             count unique             top freq          mean
std  \
state         1000      2  Andhra Pradesh  797           NaN
NaN
district      1000      5        A0Ntapur  788           NaN
NaN
year        1000.0    NaN             NaN  NaN       2005.98
5.023429
season        1000      4          Kharif  394           NaN
NaN
crop          1000     63            Rice   54           NaN
NaN
area        1000.0    NaN             NaN  NaN   19062.38207
98732.451398
production  1000.0    NaN             NaN  NaN  799876.82899
6059522.740398
Unnamed: 7     0.0    NaN             NaN  NaN           NaN
```

```
NaN
```

```
                min     25%     50%       75%          max
state           NaN     NaN     NaN       NaN          NaN
district        NaN     NaN     NaN       NaN          NaN
year         1997.0  2002.0  2006.0    2010.0       2014.0
season          NaN     NaN     NaN       NaN          NaN
crop            NaN     NaN     NaN       NaN          NaN
area            0.2  98.495   787.0   4196.25     877029.0
production      0.0   101.5  1187.5  12226.25  71300000.0
Unnamed: 7      NaN     NaN     NaN       NaN          NaN

Missing Values:
state            0
district         0
year             0
season           0
crop             0
area             0
production       0
Unnamed: 7    1000
dtype: int64

Unique entries per column:

state           2
district        5
year           18
season          4
crop           63
area          779
production    811
Unnamed: 7      0
dtype: int64
```

```
# --- RAINFALL DATASET OVERVIEW ---
print("\n\nRAINFALL DATASET INFO:")
print(rain_df.info())
print("\nBasic Stats:")
print(rain_df.describe(include='all').transpose())

print("\nMissing Values:")
print(rain_df.isnull().sum())

print("\nUnique entries per column:")
print(rain_df.nunique())
```

```


RAINFALL DATASET INFO:
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 1000 entries, 0 to 999
Data columns (total 16 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   subdivision  1000 non-null   object
 1   year         1000 non-null   int64
 2   jan          1000 non-null   float64
 3   feb          1000 non-null   float64
 4   mar          1000 non-null   float64
 5   apr          1000 non-null   float64
 6   may          1000 non-null   float64
 7   jun          1000 non-null   float64
 8   jul          1000 non-null   float64
 9   aug          1000 non-null   float64
 10  sep          1000 non-null   float64
 11  oct          1000 non-null   float64
 12  nov          1000 non-null   float64
 13  dec          1000 non-null   float64
 14  annual       1000 non-null   float64
 15  jjas         1000 non-null   float64
dtypes: float64(14), int64(1), object(1)
memory usage: 125.1+ KB
None

Basic Stats:
              count unique                top freq       mean
std  \
subdivision    1000      9  Assam & Meghalaya  117        NaN
NaN
year         1000.0    NaN                NaN  NaN   1958.578
33.172071
jan          1000.0    NaN                NaN  NaN    22.1072
34.247224
feb          1000.0    NaN                NaN  NaN    31.6094
35.585764
mar          1000.0    NaN                NaN  NaN    50.8319
60.667716
apr          1000.0    NaN                NaN  NaN   104.0455
103.235944
may          1000.0    NaN                NaN  NaN    210.222
161.408607
jun          1000.0    NaN                NaN  NaN    380.384
215.478401
jul          1000.0    NaN                NaN  NaN   443.6459
203.285876
aug          1000.0    NaN                NaN  NaN    391.509
153.985821
sep          1000.0    NaN                NaN  NaN   316.1266
140.204319
```

```
oct           1000.0    NaN                  NaN  NaN   148.0506
106.904723
nov           1000.0    NaN                  NaN  NaN    47.3628
82.271416
dec           1000.0    NaN                  NaN  NaN    24.9264
64.938764
annual        1000.0    NaN                  NaN  NaN  2138.7846
889.538882
jjas          1000.0    NaN                  NaN  NaN   1526.921
554.231665

                 min       25%      50%       75%     max
subdivision      NaN       NaN      NaN       NaN     NaN
year          1901.0    1930.0   1959.0    1986.0  2017.0
jan              0.0       3.1    11.75    28.025   583.7
feb              0.0       6.9     19.8      42.4   306.3
mar              0.0       8.6     29.3      74.4   605.6
apr              0.0      22.6     64.7    161.35   595.1
may              0.0    66.375   195.75   308.225  1168.6
jun              0.0   200.375    362.2    511.05  1609.9
jul              0.0   315.225   400.85   511.525  2362.8
aug              0.0   293.025    363.5    450.35  1664.6
sep              0.0     219.0   288.05   380.725  1222.0
oct              0.0    67.525   131.25   202.675   948.3
nov              0.0     3.075    14.75    47.925   648.9
dec              0.0       0.3      3.7    16.325   617.5
annual           0.0  1396.075  2169.15   2743.95  6331.1
jjas             0.0  1123.225  1412.75  1814.225  4534.5

Missing Values:
subdivision    0
year           0
jan            0
feb            0
mar            0
apr            0
may            0
jun            0
jul            0
aug            0
sep            0
oct            0
nov            0
dec            0
annual         0
jjas           0
dtype: int64

Unique entries per column:
subdivision      9
```

```
year            117
jan             444
feb             543
mar             627
apr             788
may             889
jun             920
jul             891
aug             892
sep             897
oct             844
nov             532
dec             359
annual          963
jjas            962
dtype: int64
```

```
# --- Final Cleaning Before Merge ---

# Drop unnecessary column
crop_df.drop(columns=["Unnamed: 7"], inplace=True)

# Rename rainfall subdivision column
rain_df.rename(columns={"subdivision": "state"}, inplace=True)

# Filter rainfall dataset to match crop years (1997–2014)
rain_df = rain_df[(rain_df["year"] >= 1997) & (rain_df["year"] <=
2014)]

# Verify ranges
print("Crop Years:", crop_df['year'].min(), "-",
crop_df['year'].max())
print("Rainfall Years:", rain_df['year'].min(), "-",
rain_df['year'].max())
```

```
Crop Years: 1997 - 2014
Rainfall Years: 1997 - 2014
```

```
# --- Merge Datasets on State and Year ---
merged_df = pd.merge(crop_df, rain_df, on=["state", "year"],
how="left")

# Check merged data
print("Merged Data Shape:", merged_df.shape)
display(merged_df.head())

# Check for any rows where rainfall info is missing (sanity check)
missing_rain = merged_df[merged_df['annual'].isnull()]
print(f"\nMissing rainfall rows: {missing_rain.shape[0]}")
```

```
Merged Data Shape: (1000, 21)
```

```
                          state  district  year      season  \
0  Andaman and Nicobar Islands  Nicobars  2000      Kharif
1  Andaman and Nicobar Islands  Nicobars  2000      Kharif
2  Andaman and Nicobar Islands  Nicobars  2000      Kharif
3  Andaman and Nicobar Islands  Nicobars  2000  Whole Year
4  Andaman and Nicobar Islands  Nicobars  2000  Whole Year

                  crop    area  production  jan  feb  mar  ...  may
jun  jul  \
0            Arecanut  1254.0      2000.0  NaN  NaN  NaN  ...  NaN
NaN  NaN
1  Other Kharifpulses     2.0         1.0  NaN  NaN  NaN  ...  NaN
NaN  NaN
2                Rice   102.0       321.0  NaN  NaN  NaN  ...  NaN
NaN  NaN
3              Banana   176.0       641.0  NaN  NaN  NaN  ...  NaN
NaN  NaN
4           Cashewnut   720.0       165.0  NaN  NaN  NaN  ...  NaN
NaN  NaN

   aug  sep  oct  nov  dec  annual  jjas
0  NaN  NaN  NaN  NaN  NaN     NaN   NaN
1  NaN  NaN  NaN  NaN  NaN     NaN   NaN
2  NaN  NaN  NaN  NaN  NaN     NaN   NaN
3  NaN  NaN  NaN  NaN  NaN     NaN   NaN
4  NaN  NaN  NaN  NaN  NaN     NaN   NaN

[5 rows x 21 columns]


Missing rainfall rows: 1000
```

```python
# Standardize names
rain_df['state'].replace({
    "Andaman & Nicobar Islands": "Andaman and Nicobar Islands"
}, inplace=True)

print("Unique states in crop dataset:")
print(crop_df['state'].unique())

print("\nUnique states in rainfall dataset:")
print(rain_df['state'].unique())
```

```
Unique states in crop dataset:
['Andaman and Nicobar Islands' 'Andhra Pradesh']

Unique states in rainfall dataset:
['Andaman and Nicobar Islands' 'Arunachal Pradesh' 'Assam & Meghalaya'
 'Naga Mani Mizo Tripura' 'Sub Himalayan West Bengal & Sikkim'
 'Gangetic West Bengal' 'Orissa' 'Jharkhand']
```

```
common_states =
list(set(crop_df['state']).intersection(set(rain_df['state'])))
crop_df = crop_df[crop_df['state'].isin(common_states)]
rain_df = rain_df[rain_df['state'].isin(common_states)]

merged_df = pd.merge(crop_df, rain_df, on=['state', 'year'],
how='left')
print("Merged Data Shape:", merged_df.shape)
print("Missing rainfall rows:", merged_df['annual'].isna().sum())
```

```
Merged Data Shape: (203, 21)
Missing rainfall rows: 0
```

```
# --- BASIC EXPLORATION ---
print("Shape of merged dataset:", merged_df.shape)
print("\nColumn names:", merged_df.columns.tolist())

print("\nData types:")
print(merged_df.dtypes)

print("\nMissing values count:")
print(merged_df.isnull().sum())

print("\nMERGED DATASET OVERVIEW\n")
display(merged_df.head())
```

```
Shape of merged dataset: (203, 21)

Column names: ['state', 'district', 'year', 'season', 'crop', 'area',
'production', 'jan', 'feb', 'mar', 'apr', 'may', 'jun', 'jul', 'aug',
'sep', 'oct', 'nov', 'dec', 'annual', 'jjas']

Data types:
state          object
district       object
year            int64
season         object
crop           object
area          float64
production    float64
jan           float64
feb           float64
mar           float64
apr           float64
may           float64
jun           float64
jul           float64
aug           float64
sep           float64
oct           float64
nov           float64
```

```
dec           float64
annual        float64
jjas          float64
dtype: object

Missing values count:
state         0
district      0
year          0
season        0
crop          0
area          0
production    0
jan           0
feb           0
mar           0
apr           0
may           0
jun           0
jul           0
aug           0
sep           0
oct           0
nov           0
dec           0
annual        0
jjas          0
dtype: int64

MERGED DATASET OVERVIEW


                          state  district  year      season  \
0  Andaman and Nicobar Islands  Nicobars  2000      Kharif
1  Andaman and Nicobar Islands  Nicobars  2000      Kharif
2  Andaman and Nicobar Islands  Nicobars  2000      Kharif
3  Andaman and Nicobar Islands  Nicobars  2000  Whole Year
4  Andaman and Nicobar Islands  Nicobars  2000  Whole Year

                  crop    area  production   jan   feb    mar  ...
may  \
0            Arecanut  1254.0      2000.0  53.0  59.0  171.3  ...
422.8
1  Other Kharifpulses     2.0         1.0  53.0  59.0  171.3  ...
422.8
2                Rice   102.0       321.0  53.0  59.0  171.3  ...
422.8
3              Banana   176.0       641.0  53.0  59.0  171.3  ...
422.8
4           Cashewnut   720.0       165.0  53.0  59.0  171.3  ...
```

```
422.8

     jun    jul    aug    sep    oct    nov    dec  annual    jjas
0  357.0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2
1  357.0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2
2  357.0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2
3  357.0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2
4  357.0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2

[5 rows x 21 columns]
```

```python
# --- SUMMARY STATISTICS ---
print("\nDescriptive statistics for numeric columns:")
print(merged_df.describe())
```

```
Descriptive statistics for numeric columns:
              year          area    production         jan         feb
\
count   203.000000    203.000000  2.030000e+02  203.000000  203.000000

mean   2005.044335   1664.512660  3.538046e+06   51.258128   16.074877

std       3.417052   3784.622998  1.305582e+07   37.597299   17.405872

min    2000.000000      0.200000  0.000000e+00    0.000000    0.000000

25%    2002.000000     46.650000  3.510500e+01   16.300000    7.900000

50%    2005.000000    145.260000  3.765000e+02   53.000000    8.000000

75%    2008.000000    950.785000  2.320000e+03   95.350000   15.700000

max    2010.000000  18394.700000  7.130000e+07  101.700000   59.000000


              mar         apr         may         jun         jul
aug  \
count  203.000000  203.000000  203.000000  203.000000  203.000000
203.000000
mean    58.661084   78.285714  378.963547  380.612808  365.458128
403.118227
std     62.701522   72.248551  113.434253   81.382040  135.266270
123.352491
min      0.700000   12.500000  296.300000  159.900000  176.300000
219.600000
25%      6.100000   15.950000  319.000000  358.300000  182.700000
308.700000
50%     36.500000   41.600000  321.400000  370.700000  378.900000
429.800000
75%    143.300000  163.700000  422.800000  448.900000  508.400000
```

```
516.400000
max    171.300000  218.100000  705.300000  452.400000  521.900000
563.800000

              sep         oct         nov         dec       annual  \
count  203.000000  203.000000  203.000000  203.000000   203.000000
mean   370.877833  319.898030  197.834975  140.673892  2761.793596
std    114.567532   74.665315   88.891678   93.195988   317.314032
min    250.100000  169.000000   74.100000    0.400000  2355.900000
25%    263.300000  267.600000   76.100000   74.400000  2404.700000
50%    334.400000  321.200000  222.600000  115.200000  2763.200000
75%    507.500000  388.550000  268.500000  246.400000  3119.000000
max    546.500000  402.400000  306.700000  283.900000  3157.100000

              jjas
count   203.000000
mean   1520.079803
std     203.080376
min    1244.200000
25%    1314.900000
50%    1515.400000
75%    1749.100000
max    1797.800000

# --- UNIQUE VALUES ---
print("\nUnique States:", merged_df['state'].unique())
print("\nUnique Seasons:", merged_df['season'].unique())
print("\nUnique Crops (sample 10):", merged_df['crop'].unique()[:10])


Unique States: ['Andaman and Nicobar Islands']

Unique Seasons: ['Kharif' 'Whole Year' 'Autumn' 'Rabi']

Unique Crops (sample 10): ['Arecanut' 'Other Kharifpulses' 'Rice'
'Banana' 'Cashewnut' 'Coconut'
 'Dry ginger' 'Sugarcane' 'Sweet potato' 'Tapioca']

# --- CORRELATION ANALYSIS ---
numeric_cols = ['area', 'production', 'annual', 'jjas', 'jun', 'jul',
'aug', 'sep']
print("\nCorrelation between crop yield and rainfall metrics:")
print(merged_df[numeric_cols].corr())


Correlation between crop yield and rainfall metrics:
                area  production    annual      jjas       jun
jul  \
area        1.000000    0.858711 -0.060200 -0.079727 -0.086405 -
0.029621
production  0.858711    1.000000 -0.034244 -0.045162 -0.053727 -
```

```
0.018017
annual     -0.060200   -0.034244  1.000000  0.814752  0.637093
0.548121
jjas       -0.079727   -0.045162  0.814752  1.000000  0.556536
0.833433
jun        -0.086405   -0.053727  0.637093  0.556536  1.000000
0.146662
jul        -0.029621   -0.018017  0.548121  0.833433  0.146662
1.000000
aug        -0.026372   -0.016019  0.794507  0.645247  0.242402
0.604723
sep        -0.016619   -0.003394 -0.510481 -0.301100 -0.157827 -
0.458155

                 aug       sep
area       -0.026372 -0.016619
production -0.016019 -0.003394
annual      0.794507 -0.510481
jjas        0.645247 -0.301100
jun         0.242402 -0.157827
jul         0.604723 -0.458155
aug         1.000000 -0.818517
sep        -0.818517  1.000000
```

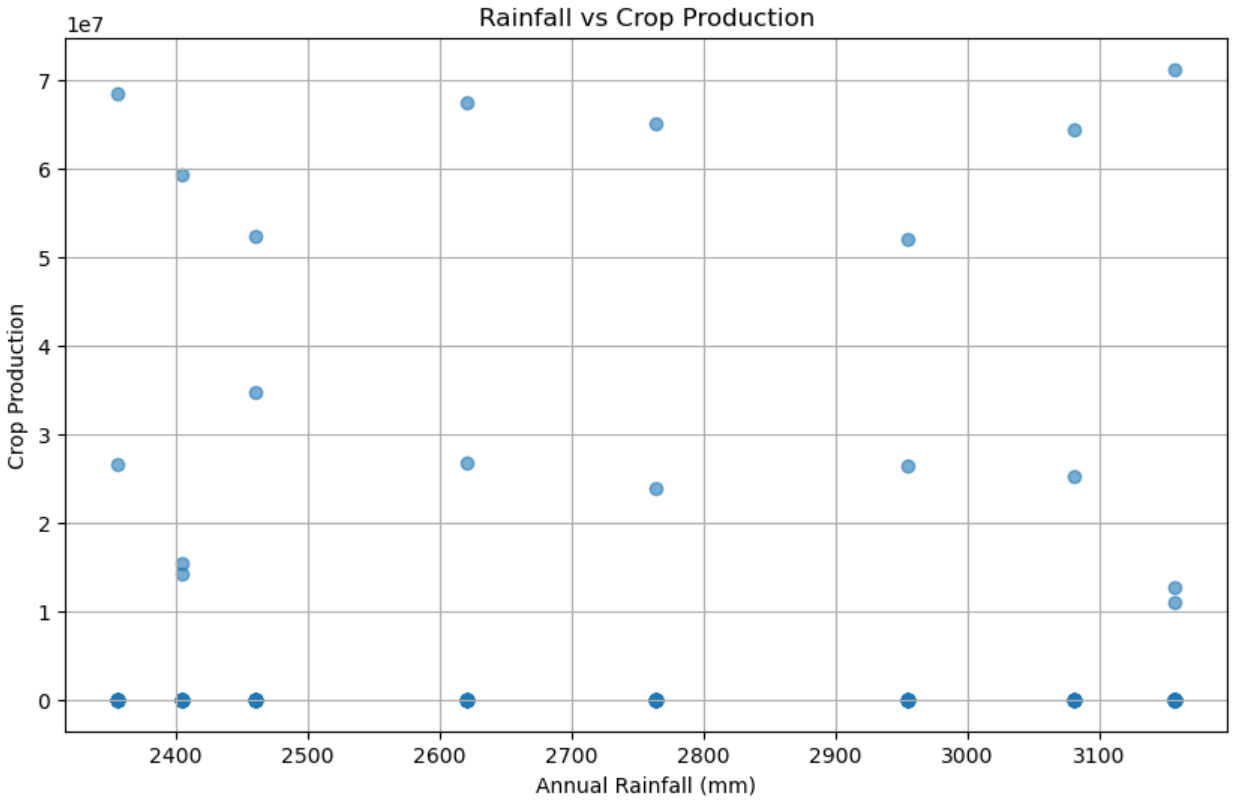
```python
# --- YIELD CALCULATION ---
merged_df['yield'] = merged_df['production'] / merged_df['area']
print("\nAverage yield by year:")
print(merged_df.groupby('year')['yield'].mean())
```

```
Average yield by year:
year
2000    337.641462
2001    449.482991
2002    398.341453
2003    397.053426
2004    407.792849
2005    361.771764
2006    342.552089
2010    228.231015
Name: yield, dtype: float64
```

```python
# --- SIMPLE VISUAL CHECK ---
import matplotlib.pyplot as plt

plt.figure(figsize=(10,6))
plt.scatter(merged_df['annual'], merged_df['production'], alpha=0.6)
plt.title('Rainfall vs Crop Production')
plt.xlabel('Annual Rainfall (mm)')
plt.ylabel('Crop Production')
```

```
plt.grid(True)
plt.show()
```




```
# Save the merged dataset to a CSV file
merged_df.to_csv("merged_crop_rainfall_data.csv", index=False)

print("□ Merged dataset successfully saved as
'merged_crop_rainfall_data.csv'")
```

```
□ Merged dataset successfully saved as 'merged_crop_rainfall_data.csv'
```

```
import pandas as pd

# Load your merged dataset
merged_df = pd.read_csv("merged_crop_rainfall_data.csv")

# Quick check
print("Shape:", merged_df.shape)
print("Columns:", merged_df.columns)
merged_df.head()
```

```
Shape: (203, 22)
Columns: Index(['state', 'district', 'year', 'season', 'crop', 'area',
'production',
       'jan', 'feb', 'mar', 'apr', 'may', 'jun', 'jul', 'aug', 'sep',
```

```
'oct',
       'nov', 'dec', 'annual', 'jjas', 'yield'],
      dtype='object')
```

```
                          state  district  year      season  \
0  Andaman and Nicobar Islands  Nicobars  2000      Kharif
1  Andaman and Nicobar Islands  Nicobars  2000      Kharif
2  Andaman and Nicobar Islands  Nicobars  2000      Kharif
3  Andaman and Nicobar Islands  Nicobars  2000  Whole Year
4  Andaman and Nicobar Islands  Nicobars  2000  Whole Year

                  crop    area  production   jan   feb    mar  ...
jun  \
0            Arecanut  1254.0      2000.0  53.0  59.0  171.3  ...
357.0
1  Other Kharifpulses     2.0         1.0  53.0  59.0  171.3  ...
357.0
2                Rice   102.0       321.0  53.0  59.0  171.3  ...
357.0
3              Banana   176.0       641.0  53.0  59.0  171.3  ...
357.0
4           Cashewnut   720.0       165.0  53.0  59.0  171.3  ...
357.0

     jul    aug    sep    oct    nov    dec  annual    jjas     yield

0  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2  1.594896

1  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2  0.500000

2  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2  3.147059

3  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2  3.642045

4  176.3  460.8  250.1  321.2  158.3  115.2  2763.2  1244.2  0.229167


[5 rows x 22 columns]
```

```
# Standardize text columns for easy querying
merged_df['state'] = merged_df['state'].str.title()
merged_df['district'] = merged_df['district'].str.title()
merged_df['crop'] = merged_df['crop'].str.title()
merged_df['season'] = merged_df['season'].str.title()

# Top yielding crops
def top_yielding_crops(year=None, top_n=5):
    df = merged_df.copy()
    if year:
        df = df[df['year'] == year]
    result = df.groupby('crop')
```

```
['yield'].mean().sort_values(ascending=False).head(top_n)
    return result

# Highest rainfall year
def highest_rainfall_year():
    return merged_df.groupby('year')['annual'].mean().idxmax()

# District with max production
def top_production_district(year=None):
    df = merged_df.copy()
    if year:
        df = df[df['year'] == year]
    return df.groupby('district')
['production'].sum().sort_values(ascending=False).head(1)

def answer_query(query):
    query = query.lower()

    # Normalize synonyms
    if "top" in query or "best" in query or "maximum" in query:
        query = query.replace("top", "highest").replace("best",
"highest").replace("maximum", "highest")

    if "highest yield" in query or ("yield" in query and "highest" in
query):
        year = next((int(word) for word in query.split() if
word.isdigit()), None)
        result = top_yielding_crops(year)
        return f"Top yielding crops in {year if year else 'overall'}:\
n{result}"

    elif "rainfall" in query and "highest" in query:
        year = highest_rainfall_year()
        return f"The year with the highest average rainfall is
{year}."

    elif "district" in query and ("production" in query or "output" in
query):
        year = next((int(word) for word in query.split() if
word.isdigit()), None)
        result = top_production_district(year)
        return f"Top district by production in {year if year else
'overall'}:\n{result}"

    else:
        return "Sorry, I couldn't understand that query. Try asking
about yield, rainfall, or production."

def top_yielding_crops(year=None):
    df = merged_df.copy()
```

```
    # Normalize column names
    df.columns = df.columns.str.lower()

    # Convert year column to numeric (just in case)
    df['year'] = pd.to_numeric(df['year'], errors='coerce')

    # Apply filter if year is provided
    if year:
        df = df[df['year'] == year]

    if df.empty:
        return f"No yield data available for {year}. Try another year
between {merged_df['year'].min()}–{merged_df['year'].max()}."


    # Group by crop and get mean yield
    result = df.groupby('crop')
['yield'].mean().sort_values(ascending=False).head(5)
    return result

# Example test
print(answer_query("Which year had the highest rainfall?"))
print(answer_query("Show top yielding crops in 2005"))
```

```
The year with the highest average rainfall is 2010.
Top yielding crops in 2005:
crop
Coconut       3749.091268
Sugarcane       19.123574
Banana          16.320926
Dry Ginger       9.000000
Turmeric         7.000612
Name: yield, dtype: float64
```

Q&A Chat Interface using Gradio

```
pip install gradio
```

```
Requirement already satisfied: gradio in
./opt/anaconda3/lib/python3.9/site-packages (4.44.0)
Requirement already satisfied: pyyaml<7.0,>=5.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (6.0)
Requirement already satisfied: gradio-client==1.3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (1.3.0)
Requirement already satisfied: aiofiles<24.0,>=22.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (23.2.1)
Requirement already satisfied: anyio<5.0,>=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (4.11.0)
Requirement already satisfied: urllib3~=2.0 in
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./opt/anaconda3/lib/python3.9/site-packages (from gradio) (2.5.0)
Requirement already satisfied: packaging in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (21.3)
Requirement already satisfied: numpy<3.0,>=1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (1.24.4)
Requirement already satisfied: matplotlib~=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (3.5.2)
Requirement already satisfied: pydantic>=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (2.12.3)
Requirement already satisfied: uvicorn>=0.14.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.38.0)
Requirement already satisfied: jinja2<4.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (2.11.3)
Requirement already satisfied: pydub in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.25.1)
Requirement already satisfied: ffmpy in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.6.4)
Requirement already satisfied: orjson~=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (3.11.4)
Requirement already satisfied: importlib-resources<7.0,>=1.3 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (6.5.2)
Requirement already satisfied: typing-extensions~=4.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (4.15.0)
Requirement already satisfied: markupsafe~=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (2.0.1)
Requirement already satisfied: pandas<3.0,>=1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (1.4.4)
Requirement already satisfied: typer<1.0,>=0.12 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.20.0)
Requirement already satisfied: python-multipart>=0.0.9 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.0.20)
Requirement already satisfied: semantic-version~=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (2.10.0)
Requirement already satisfied: ruff>=0.2.2 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.14.3)
Requirement already satisfied: fastapi<1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.120.4)
Requirement already satisfied: huggingface-hub>=0.19.3 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.23.0)
Requirement already satisfied: pillow<11.0,>=8.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (9.2.0)
Requirement already satisfied: httpx>=0.24.1 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.28.1)
Requirement already satisfied: tomlkit==0.12.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio) (0.12.0)
Requirement already satisfied: websockets<13.0,>=10.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio-
client==1.3.0->gradio) (12.0)
Requirement already satisfied: fsspec in
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./opt/anaconda3/lib/python3.9/site-packages (from gradio-
client==1.3.0->gradio) (2025.10.0)
Requirement already satisfied: sniffio>=1.1 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio) (1.2.0)
Requirement already satisfied: idna>=2.8 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio) (3.3)
Requirement already satisfied: exceptiongroup>=1.0.2 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio) (1.3.0)
Requirement already satisfied: starlette<0.50.0,>=0.40.0 in
./opt/anaconda3/lib/python3.9/site-packages (from fastapi<1.0->gradio)
(0.49.1)
Requirement already satisfied: annotated-doc>=0.0.2 in
./opt/anaconda3/lib/python3.9/site-packages (from fastapi<1.0->gradio)
(0.0.3)
Requirement already satisfied: httpcore==1.* in
./opt/anaconda3/lib/python3.9/site-packages (from httpx>=0.24.1-
>gradio) (1.0.9)
Requirement already satisfied: certifi in
./opt/anaconda3/lib/python3.9/site-packages (from httpx>=0.24.1-
>gradio) (2024.8.30)
Requirement already satisfied: h11>=0.16 in
./opt/anaconda3/lib/python3.9/site-packages (from httpcore==1.*-
>httpx>=0.24.1->gradio) (0.16.0)
Requirement already satisfied: tqdm>=4.42.1 in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio) (4.64.1)
Requirement already satisfied: filelock in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio) (3.6.0)
Requirement already satisfied: requests in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio) (2.31.0)
Requirement already satisfied: zipp>=3.1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from importlib-
resources<7.0,>=1.3->gradio) (3.8.0)
Requirement already satisfied: kiwisolver>=1.0.1 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio) (1.4.2)
Requirement already satisfied: python-dateutil>=2.7 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio) (2.8.2)
Requirement already satisfied: pyparsing>=2.2.1 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio) (3.0.9)
Requirement already satisfied: cycler>=0.10 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
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>gradio) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio) (4.25.0)
Requirement already satisfied: pytz>=2020.1 in
./opt/anaconda3/lib/python3.9/site-packages (from pandas<3.0,>=1.0-
>gradio) (2024.1)
Requirement already satisfied: pydantic-core==2.41.4 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio) (2.41.4)
Requirement already satisfied: typing-inspection>=0.4.2 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio) (0.4.2)
Requirement already satisfied: annotated-types>=0.6.0 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio) (0.7.0)
Requirement already satisfied: rich>=10.11.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio) (14.2.0)
Requirement already satisfied: click>=8.0.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio) (8.0.4)
Requirement already satisfied: shellingham>=1.3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio) (1.5.4)
Requirement already satisfied: six>=1.5 in
./opt/anaconda3/lib/python3.9/site-packages (from python-
dateutil>=2.7->matplotlib~=3.0->gradio) (1.16.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in
./opt/anaconda3/lib/python3.9/site-packages (from rich>=10.11.0-
>typer<1.0,>=0.12->gradio) (2.19.2)
Requirement already satisfied: markdown-it-py>=2.2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from rich>=10.11.0-
>typer<1.0,>=0.12->gradio) (3.0.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface-hub>=0.19.3->gradio) (2.0.4)
Requirement already satisfied: mdurl~=0.1 in
./opt/anaconda3/lib/python3.9/site-packages (from markdown-it-
py>=2.2.0->rich>=10.11.0->typer<1.0,>=0.12->gradio) (0.1.2)
Note: you may need to restart the kernel to use updated packages.

!pip install --upgrade gradio==4.44.0
!pip install --upgrade huggingface_hub==0.23.0

Requirement already satisfied: gradio==4.44.0 in
./opt/anaconda3/lib/python3.9/site-packages (4.44.0)
Requirement already satisfied: matplotlib~=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(3.5.2)
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Requirement already satisfied: typer<1.0,>=0.12 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.20.0)
Requirement already satisfied: semantic-version~=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(2.10.0)
Requirement already satisfied: typing-extensions~=4.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(4.15.0)
Requirement already satisfied: httpx>=0.24.1 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.28.1)
Requirement already satisfied: orjson~=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(3.11.4)
Requirement already satisfied: pillow<11.0,>=8.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(9.2.0)
Requirement already satisfied: packaging in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(21.3)
Requirement already satisfied: huggingface-hub>=0.19.3 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.23.0)
Requirement already satisfied: tomlkit==0.12.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.12.0)
Requirement already satisfied: ffmpy in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.6.4)
Requirement already satisfied: ruff>=0.2.2 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.14.3)
Requirement already satisfied: gradio-client==1.3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(1.3.0)
Requirement already satisfied: pyyaml<7.0,>=5.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(6.0)
Requirement already satisfied: anyio<5.0,>=3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(4.11.0)
Requirement already satisfied: urllib3~=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(2.5.0)
Requirement already satisfied: numpy<3.0,>=1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(1.24.4)
Requirement already satisfied: importlib-resources<7.0,>=1.3 in
```

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./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(6.5.2)
Requirement already satisfied: pydantic>=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(2.12.3)
Requirement already satisfied: fastapi<1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.120.4)
Requirement already satisfied: python-multipart>=0.0.9 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.0.20)
Requirement already satisfied: markupsafe~=2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(2.0.1)
Requirement already satisfied: pandas<3.0,>=1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(1.4.4)
Requirement already satisfied: jinja2<4.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(2.11.3)
Requirement already satisfied: pydub in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.25.1)
Requirement already satisfied: uvicorn>=0.14.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(0.38.0)
Requirement already satisfied: aiofiles<24.0,>=22.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio==4.44.0)
(23.2.1)
Requirement already satisfied: websockets<13.0,>=10.0 in
./opt/anaconda3/lib/python3.9/site-packages (from gradio-
client==1.3.0->gradio==4.44.0) (12.0)
Requirement already satisfied: fsspec in
./opt/anaconda3/lib/python3.9/site-packages (from gradio-
client==1.3.0->gradio==4.44.0) (2025.10.0)
Requirement already satisfied: sniffio>=1.1 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio==4.44.0) (1.2.0)
Requirement already satisfied: exceptiongroup>=1.0.2 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio==4.44.0) (1.3.0)
Requirement already satisfied: idna>=2.8 in
./opt/anaconda3/lib/python3.9/site-packages (from anyio<5.0,>=3.0-
>gradio==4.44.0) (3.3)
Requirement already satisfied: annotated-doc>=0.0.2 in
./opt/anaconda3/lib/python3.9/site-packages (from fastapi<1.0-
>gradio==4.44.0) (0.0.3)
Requirement already satisfied: starlette<0.50.0,>=0.40.0 in
./opt/anaconda3/lib/python3.9/site-packages (from fastapi<1.0-
```

```
>gradio==4.44.0) (0.49.1)
Requirement already satisfied: certifi in
./opt/anaconda3/lib/python3.9/site-packages (from httpx>=0.24.1-
>gradio==4.44.0) (2024.8.30)
Requirement already satisfied: httpcore==1.* in
./opt/anaconda3/lib/python3.9/site-packages (from httpx>=0.24.1-
>gradio==4.44.0) (1.0.9)
Requirement already satisfied: h11>=0.16 in
./opt/anaconda3/lib/python3.9/site-packages (from httpcore==1.*-
>httpx>=0.24.1->gradio==4.44.0) (0.16.0)
Requirement already satisfied: tqdm>=4.42.1 in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio==4.44.0) (4.64.1)
Requirement already satisfied: filelock in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio==4.44.0) (3.6.0)
Requirement already satisfied: requests in
./opt/anaconda3/lib/python3.9/site-packages (from huggingface-
hub>=0.19.3->gradio==4.44.0) (2.31.0)
Requirement already satisfied: zipp>=3.1.0 in
./opt/anaconda3/lib/python3.9/site-packages (from importlib-
resources<7.0,>=1.3->gradio==4.44.0) (3.8.0)
Requirement already satisfied: python-dateutil>=2.7 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio==4.44.0) (2.8.2)
Requirement already satisfied: fonttools>=4.22.0 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio==4.44.0) (4.25.0)
Requirement already satisfied: cycler>=0.10 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio==4.44.0) (0.11.0)
Requirement already satisfied: pyparsing>=2.2.1 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio==4.44.0) (3.0.9)
Requirement already satisfied: kiwisolver>=1.0.1 in
./opt/anaconda3/lib/python3.9/site-packages (from matplotlib~=3.0-
>gradio==4.44.0) (1.4.2)
Requirement already satisfied: pytz>=2020.1 in
./opt/anaconda3/lib/python3.9/site-packages (from pandas<3.0,>=1.0-
>gradio==4.44.0) (2024.1)
Requirement already satisfied: typing-inspection>=0.4.2 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio==4.44.0) (0.4.2)
Requirement already satisfied: annotated-types>=0.6.0 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio==4.44.0) (0.7.0)
Requirement already satisfied: pydantic-core==2.41.4 in
./opt/anaconda3/lib/python3.9/site-packages (from pydantic>=2.0-
>gradio==4.44.0) (2.41.4)
```

```
Requirement already satisfied: shellingham>=1.3.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio==4.44.0) (1.5.4)
Requirement already satisfied: rich>=10.11.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio==4.44.0) (14.2.0)
Requirement already satisfied: click>=8.0.0 in
./opt/anaconda3/lib/python3.9/site-packages (from typer<1.0,>=0.12-
>gradio==4.44.0) (8.0.4)
Requirement already satisfied: six>=1.5 in
./opt/anaconda3/lib/python3.9/site-packages (from python-
dateutil>=2.7->matplotlib~=3.0->gradio==4.44.0) (1.16.0)
Requirement already satisfied: markdown-it-py>=2.2.0 in
./opt/anaconda3/lib/python3.9/site-packages (from rich>=10.11.0-
>typer<1.0,>=0.12->gradio==4.44.0) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in
./opt/anaconda3/lib/python3.9/site-packages (from rich>=10.11.0-
>typer<1.0,>=0.12->gradio==4.44.0) (2.19.2)
Requirement already satisfied: charset-normalizer<4,>=2 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface-hub>=0.19.3->gradio==4.44.0) (2.0.4)
Requirement already satisfied: mdurl~=0.1 in
./opt/anaconda3/lib/python3.9/site-packages (from markdown-it-
py>=2.2.0->rich>=10.11.0->typer<1.0,>=0.12->gradio==4.44.0) (0.1.2)
Requirement already satisfied: huggingface_hub==0.23.0 in
./opt/anaconda3/lib/python3.9/site-packages (0.23.0)
Requirement already satisfied: filelock in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (3.6.0)
Requirement already satisfied: fsspec>=2023.5.0 in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (2025.10.0)
Requirement already satisfied: requests in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (2.31.0)
Requirement already satisfied: pyyaml>=5.1 in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (6.0)
Requirement already satisfied: packaging>=20.9 in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (21.3)
Requirement already satisfied: typing-extensions>=3.7.4.3 in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (4.15.0)
Requirement already satisfied: tqdm>=4.42.1 in
./opt/anaconda3/lib/python3.9/site-packages (from
huggingface_hub==0.23.0) (4.64.1)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
./opt/anaconda3/lib/python3.9/site-packages (from packaging>=20.9-
```

```
>huggingface_hub==0.23.0) (3.0.9)
Requirement already satisfied: certifi>=2017.4.17 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface_hub==0.23.0) (2024.8.30)
Requirement already satisfied: urllib3<3,>=1.21.1 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface_hub==0.23.0) (2.5.0)
Requirement already satisfied: idna<4,>=2.5 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface_hub==0.23.0) (3.3)
Requirement already satisfied: charset-normalizer<4,>=2 in
./opt/anaconda3/lib/python3.9/site-packages (from requests-
>huggingface_hub==0.23.0) (2.0.4)
```

```
import gradio as gr

def qa_chat(query):
    response = answer_query(query)
    return response

iface = gr.Interface(
    fn=qa_chat,
    inputs=gr.Textbox(lines=2, placeholder="Ask a question like 'Top
yielding crop in 2005'..."),
    outputs="text",
    title="Crop & Rainfall Insights Chat System",
    description="Ask questions about rainfall, production, or yield.
Data is based on merged crop-rainfall dataset."
)

iface.launch()
```

```
Running on local URL:  http://127.0.0.1:7860

To create a public link, set `share=True` in `launch()`.

<IPython.core.display.HTML object>



/Users/sakshi/opt/anaconda3/lib/python3.9/site-packages/gradio/
analytics.py:106: UserWarning: IMPORTANT: You are using gradio version
4.44.0, however version 4.44.1 is available, please upgrade.
--------
  warnings.warn(
```