Power BI Capstone Project Report

Data Preprocessing :

As part of preparing the dataset for analysis, the following preprocessing steps were carried out:

1. **Null Value Removal**
    - All rows containing `null` values in any column were removed to ensure data completeness and integrity.
2. **Altitude Column Transformation**
    - The original `altitude` column (a string field) was split into two numeric columns:
        - `altitude_min`
        - `altitude_max`
    - This conversion allowed more accurate range-based analysis.
3. **Unit Stripping and Type Conversion**

- Columns containing numeric values with units (e.g., `"1200 m"`) had the units removed.

- These columns were then converted to integers to enable numerical computations.

4. **Expiry Analysis**

   - A new column `days_remaining_before_expiry` was calculated from expiry dates.

   - However, all values were found to be constant across records, so this feature had no impact on further analysis.

5. **Defect Normalization**

   - A `defects_per_tonne` column was created to normalize defect data by weight, enabling fair comparisons across samples.

6. **Correlation Measures**

   - We computed correlations between coffee quality and:

     - Sensory attributes (e.g., aroma, acidity, flavor)

        - `defects_per_tonne`
        - `quakers_per_tonne`

7. **Extended Analyses (See Extra Pages)**
    - Share of different **processing methods** used globally.
    - **Regional contributions** to global average coffee quality.

Refer to pages with respective question numbers like Q.1.) ,Q.2.),Q.3.),Extra and Q.4.) marked for further validation and reference .Also make note that we used the observations and visuals from questions 1,2, and 3 to answer question 4 properly.

1.What are the key determinants of coffee quality as evaluated through sensory attributes such as aroma, flavor, acidity, etc.?

This report identifies the key determinants of coffee quality as evaluated through sensory attributes, revealing a strong hierarchical influence where **Flavor, Aftertaste, and Balance** are the most critical factors. These attributes, along with Acidity, Aroma, and Body, significantly contribute

to the overall perceived quality. Crucially, environmental and cultivation factors such as **altitude, moisture percentage of coffee beans, processing method, and coffee variety** profoundly influence these sensory attributes, thereby indirectly dictating the final coffee quality score. Notably, specific combinations of region, variety, and processing consistently yield superior sensory profiles.

Part 1: Direct Determinants of Overall Coffee Quality (Total Cup Points)

Research Question: What are the key determinants of coffee quality as evaluated through sensory attributes such as aroma, flavor, acidity, etc.?

Answer: The primary determinants of overall coffee quality (Total Cup Points) are **Flavor (r=0.94), Aftertaste (r=0.93), and Balance (r=0.93)**. These "taste-related" attributes exhibit the strongest positive linear correlation with the composite quality score, indicating that they are the most heavily weighted factors in professional cupping evaluations. Acidity (r=0.90), Aroma (r=0.87), and Body (r=0.85) also show very strong positive correlations, serving as significant contributors to quality. Attributes like Uniformity, Sweetness, and Clean Cup demonstrate negligible correlation (r≈0.00), suggesting they often function as prerequisite "hygiene factors" that are consistently met in the dataset rather than differentiating factors for high quality.

Analytical Approach

To investigate the relationship between sensory attributes and overall coffee quality, we analyzed a dataset containing various cupping scores. We assessed how each sensory attribute correlates with "Total Cup Points," a composite score reflecting perceived coffee quality. The Pearson correlation coefficient was used to quantify the strength and direction of the linear relationship between each individual sensory attribute and the Total Cup Points .We also plotted mean plots of coffee quality(on Pages indexed as Q.1.)mean plots of various sensory attributes) against the various sensory attributes and added slicers on the correlation comparison plot (on pages indexed as Q.1.)Correlation) to visualize the effects of varietal, environmental factors on coffee quality.

Correlation Results with Total Cup Points:

Sensory Attribute	**Correlation with Total Cup Points**
Flavor	0.94
Aftertaste	0.93
Balance	0.93
Acidity	0.90

Aroma	0.87
Body	0.85
Uniformity	~0.00
Sweetness	~0.00
Clean Cup	~0.00

Insights on Direct Determinants:

- **Highly Influential Attributes:** Flavor, Aftertaste, and Balance are paramount. Their very high correlation coefficients (≥0.93) emphasize that the core taste experience, its lingering impression, and the harmonious interplay of all sensory components are the most critical drivers of overall coffee quality.
- **Moderately Correlated Features:** Acidity, Aroma, and Body contribute significantly. While not as dominant as the top three, their strong positive correlations (≥0.85) indicate that a pleasant acidity, appealing fragrance, and desirable mouthfeel are essential elements of a high-quality cup.
- **Zero Correlation (Hygiene Factors):** Uniformity, Sweetness, and Clean Cup consistently score high for almost all coffee samples in the dataset. This suggests they are either baseline requirements for specialty coffee (i.e., a "clean cup" with uniform characteristics

and inherent sweetness is expected) or represent attributes where differentiation among samples is minimal, thus not acting as primary drivers of *variation* in overall quality score within this specific dataset.

Part 2: Indirect Influences on Coffee Quality via Sensory Attributes

This section details how environmental and typical factors (moisture percentage of coffee beans, processing methods, coffee variety, altitude, and origin region) influence individual sensory attributes, thereby indirectly impacting overall coffee quality.

2.1 How does Aroma get affected by different environmental and typical factors?

Influence on Aroma: Aroma, with a strong positive correlation (r=0.87) to Total Cup Points, is a crucial precursor to flavor. Factors that enhance or detract from aroma directly influence the perception of overall coffee quality.

Factors and Trends:

- **Altitude and Moisture Percentage:**
    - **Trend:** Coffee grown at **higher altitudes (>3000 ft)** with **optimal moisture percentage (10-12%)** shows varied aroma depending on processing. However, generally, higher altitudes are associated with more complex aromatic precursors.
    - **Indirect Impact:** Optimal moisture prevents the development of off-aromas (e.g., musty, moldy)

and preserves volatile aromatic compounds, directly supporting a higher overall quality score.

- **Processing Methods:**
    - **Trend:** At >3000 ft and optimal moisture, **Natural/Dry** methods tend to yield the **highest aroma scores** (e.g., Bourbon with 7.8), followed by Washed/Wet (e.g., Bourbon with ~7.58), and then Pulped Natural/Honey (e.g., Catimor with lowest aroma at ~7.58).
    - **Contradictory Observation:** For Maragogype, Natural/Dry at 1000-1500 ft (6.50) yields lower aroma than Washed/Wet at 500-1000 ft (7.33). This indicates that the "best" processing method for aroma is highly context-dependent, relying on varietal and regional interaction.
    - **Double Anaerobic Washed** stands out for **highest aroma** (Castillo, 8.58).
    - **Indirect Impact:** Processing significantly impacts aroma by influencing fermentation and drying. Natural/Dry methods can concentrate fruitier aromas, while Washed/Wet often yields cleaner, brighter aromatics. Specialized methods like Double Anaerobic Washed can create unique, intense aromatics. The choice of processing method, optimized for the bean and environment, directly translates to the aromatic complexity contributing to higher overall quality.
- **Coffee Variety:**

    - **Trend for Lower Aroma: Maragogype** (especially Natural/Dry at 1000-1500 ft, El Salvador, 6.50) and **Gayo** (1000-1500 ft, Washed/Wet, 7.1) consistently yield lower aroma scores. Varieties like Catuaí Mundo Novo and Castillo Caturra Bourbon (Washed/Wet) also score relatively low.
    - **Trend for Higher Aroma: Geisha, (Wolishalo, Kurume, Dega), SL34+Geisha, Red Bourbon, and Castillo** are consistently associated with **high aroma scores (>8)**. Castillo, with Double Anaerobic Washed processing, achieves the highest aroma score of 8.58.
    - **Indirect Impact:** Varietal genetics play a fundamental role in producing aromatic precursors. High-aroma varieties inherently contribute to better aroma scores and, by extension, higher Total Cup Points. Certain varieties might also react differently to processing methods, emphasizing the importance of varietal-specific processing.
- **Origin Country/Region:**

    - **Trend:** El Salvador (Maragogype, Pacas) and Vietnam (Catimor) show tendencies for lower aroma in specific regional/varietal combinations. Conversely, **Taiwan (SL34+Geisha, Geisha)**, **Colombia (Red Bourbon, Castillo)**, and **Ethiopia (Wolishalo, Kurume, Dega)** are consistently associated with **high aroma scores**.

- **Indirect Impact:** Regional microclimates (temperature, rainfall) influence bean development and drying, which directly impacts aroma retention and development. A region's established processing expertise can also elevate aroma quality.

2.2 How does Acidity get affected by different environmental and typical factors?

Influence on Acidity: Acidity (r=0.90) contributes significantly to coffee's vibrancy, brightness, and overall quality. Well-balanced acidity is highly sought after in specialty coffee.

Factors and Trends:

- **Altitude:**
    - **Trend:** Higher altitudes (1500-2500 ft) are consistently associated with **higher acidity** (e.g., Castillo at 1500-2000 ft, Red Bourbon at 2000-2500 ft, Wolishalo/Kurume/Dega at 2000-2500 ft, Ethiopian Heirlooms at 2000-2500 ft). Lower altitudes (500-1000 ft) are linked to lower acidity (e.g., Yellow Catuai, Catucai, Mundo Novo in Brazil).
    - **Indirect Impact:** Slower maturation at higher altitudes allows for more complex acid development (e.g., malic, citric), which translates to a more vibrant and desirable acidity, thereby boosting overall quality.

- **Moisture Percentage of Coffee Beans:**
    - **Trend:** While optimal moisture is the norm for high acidity, high moisture content for Ethiopian Heirlooms (Natural/Dry) still yields high acidity (8.00), suggesting that some varieties and processes can maintain acidity even with slightly higher initial moisture, perhaps due to quick drying.
    - **Indirect Impact:** Proper moisture management during drying prevents off-flavors that would mask or negatively impact the perception of desirable acidity.
- **Processing Methods:**
    - **Trend: Double Anaerobic Washed (Castillo, 8.58) and Honey/Mossto (Red Bourbon, 8.25)** lead to the highest acidity scores. Washed/Wet also produces high acidity (Wolishalo/Kurume/Dega, 8.17; Ethiopian Heirlooms, 8.00-8.17). Natural/Dry can yield high acidity (SL34+Geisha, 8.00; Ethiopian Heirlooms, 8.00-8.08), but also lower acidity (Catuaí Mundo Novo, 7.08).
    - **Indirect Impact:** Processing methods profoundly shape acidity. Washed methods often highlight clean, crisp acids. Natural methods can produce softer, fruitier acids. Specialized methods like anaerobic fermentation can create unique, intense acid profiles, directly contributing to the complexity and score of the coffee.

- **Coffee Variety:**
    - **Trend for Lower Acidity: Catuaí Mundo Novo (7.08), Yellow Catuai, Catucai, Mundo Novo** are consistently among the least acidic, predominantly found in Brazil.
    - **Trend for Higher Acidity: Castillo, Red Bourbon, SL34+Geisha, (Wolishalo, Kurume, Dega), and Ethiopian Heirlooms** are the most acidic varieties.
    - **Indirect Impact:** Varietal genetics determine the potential acid profile. Cultivating varieties known for desirable acidity in suitable environments is key to achieving high-quality coffee.
- **Origin Country/Region:**
    - **Trend: Colombia** (Castillo, Red Bourbon) and **Ethiopia** (Wolishalo/Kurume/Dega, Ethiopian Heirlooms) consistently produce coffees with **high acidity**. Brazil often shows lower acidity for some varieties. The Sarchimor variety shows higher acidity in Mexico than Nicaragua, even with similar conditions and processing.
    - **Indirect Impact:** Regional climate, soil, and processing expertise can foster specific acid development. Dry season harvesting in regions like Mexico and Nicaragua, despite similarities, highlights regional variations in how environmental conditions interact with processing to affect acidity.

2.3 How does Aftertaste get affected by different environmental and typical factors?

Influence on Aftertaste: Aftertaste (r=0.93) is a critical component of coffee quality, signifying the lingering pleasantness and complexity of flavor perception. A clean, long, and pleasant aftertaste significantly elevates the overall cupping score.

Factors and Trends:

- **Altitude and Moisture Percentage:**
    - **Trend:** Higher altitudes (1500-2500 ft) are consistently associated with **longer and more pleasant aftertastes** (e.g., Castillo, Red Bourbon, Wolishalo/Kurume/Dega, Geisha). Optimal moisture content supports these attributes.
    - **Indirect Impact:** Proper bean development at higher altitudes and optimal moisture content contribute to the complexity of compounds that create a lasting and desirable aftertaste, directly boosting quality.
- **Processing Methods:**
    - **Trend: Double Anaerobic Washed (Castillo, 8.42)** and **Honey/Mossto (Red Bourbon, 8.08)** produce the highest aftertaste scores. Washed/Wet also yields high scores (Wolishalo/Kurume/Dega, 7.92; Geisha in Costa Rica, Guatemala, Taiwan). Natural/Dry can produce high scores (SL34+Gesha, 8.17; Geisha

in Ethiopia, 8.00), but also low scores (Pacas, Maragogype in El Salvador).
    - **Indirect Impact:** Processing methods greatly influence the retention and development of flavor compounds that contribute to aftertaste. Fermentation (anaerobic, honey) can create complex, lingering notes, while efficient washing (Washed/Wet) can ensure a clean finish.
- **Coffee Variety:**
    - **Trend for Lower Aftertaste: Pacas (7.08), Maragogype (7.13), Mundo Novo (6.67-7.50), Catuai and Mundo Novo (7.17)** often show lower aftertaste scores, particularly from El Salvador and Brazil.
    - **Trend for Higher Aftertaste: Castillo, SL34+Gesha, Red Bourbon, Wolishalo/Kurume/Dega, and Geisha** consistently achieve **high aftertaste scores (>7.90)**.
    - **Indirect Impact:** Varietal genetics determine the array of compounds available to create aftertaste. Selecting varieties known for their lingering qualities enhances overall quality.
- **Origin Country/Region:**
    - **Trend: Colombia (Castillo, Red Bourbon), Taiwan (SL34+Gesha, Geisha), Ethiopia (Wolishalo/Kurume/Dega, Geisha), and Guatemala (Geisha)** consistently produce coffees with **superior aftertaste**. El Salvador and certain

regions in Brazil (Mundo Novo) tend to have lower aftertaste scores.
    - **Indirect Impact:** Regional environmental conditions and processing expertise contribute to the proper development and retention of aftertaste compounds. The consistency of high aftertaste in regions like Colombia and Taiwan highlights their dedication to quality control throughout processing.

2.4 How does Flavor get affected by different environmental and typical factors?

Influence on Flavor: Flavor (r=0.94) is the most dominant sensory attribute influencing overall quality. It is the composite perception of taste, aroma, and mouthfeel, making it highly sensitive to all upstream factors.

Factors and Trends:

- **Altitude and Moisture Percentage:**
    - **Trend:** Higher altitudes (1500-2500 ft) generally yield **higher flavor complexity and intensity** (e.g., Castillo, Red Bourbon, Geisha). Optimal moisture content is crucial for flavor development and preservation. Lower altitudes can lead to slightly less complex flavor (Geisha in Taiwan at 500-1000 ft scores 8.04 vs 8.11 at 1000-1500 ft).
    - **Indirect Impact:** Slower maturation at high altitudes and careful moisture management allows for the full development of flavor precursors and

prevents defects that would compromise flavor, directly boosting overall quality.

- **Processing Methods:**
    - **Trend: Double Anaerobic Washed (Castillo, 8.50) and Honey/Mossto (Red Bourbon, 8.33)** consistently lead to the highest flavor scores, indicating their ability to develop complex and intense flavors. **Natural/Dry** can yield very high flavor (SL34+Gesha, 8.25; Geisha in Taiwan, 8.17) but also low (Maragogype, 6.75). **Washed/Wet** also produces high flavor (Geisha in Taiwan, 8.17; Wolishalo/Kurume/Dega).
    - **Contradictory Observation:** For Geisha in Taiwan, November low moisture content reverses the trend for Natural/Dry (7.92) vs. Washed/Wet (8.05), highlighting the interaction of moisture and processing.
    - **Indirect Impact:** Processing is foundational to flavor. Anaerobic and Honey methods are celebrated for their ability to create unique and often intense flavor profiles. Natural processing can enhance fruit notes. Washed processing often results in cleaner, brighter flavors. The optimal choice directly impacts the "taste-related" attributes that dominate overall quality.
- **Coffee Variety:**
    - **Trend for Lower Flavor: Maragogype (6.75), Catuai and Mundo Novo (7.17), Typica**

Bourbon Caturra Catimor (7.25), Pacas (7.25) are consistently among the lowest flavor scorers.
    - **Trend for Higher Flavor: Red Bourbon, Castillo, SL34+Gesha, Geisha, (Wolishalo, Kurume, Dega), and Yellow Bourbon** are the highest flavor scoring varieties.
    - **Indirect Impact:** Varietal genetics are the blueprint for flavor. High-scoring varieties inherently possess a greater potential for complex and desirable flavor, making them crucial for achieving top-tier quality.
- **Origin Country/Region:**

    - **Trend: Colombia (Castillo, Red Bourbon), Taiwan (SL34+Gesha, Geisha), and Ethiopia (Wolishalo/Kurume/Dega)** are consistently associated with **superior flavor**. El Salvador and certain regions in Brazil and Thailand tend to produce lower-flavor coffees.
    - **Indirect Impact:** Regional climate, soil, and the expertise of local producers in cultivation and processing profoundly influence flavor development and preservation. Regions with a strong reputation for flavor often have long-standing traditions of meticulous handling.

2.5 How does Body get affected by different environmental and typical factors?

Influence on Body: Body (r=0.85) refers to the tactile sensation or mouthfeel of the coffee. A desirable body adds

to the perceived richness and completeness of the cup, contributing meaningfully to overall quality.

Factors and Trends:

- **Altitude and Moisture Percentage:**
    - **Trend:** Higher altitudes (1500-2500 ft) are strongly associated with a **fuller, more desirable body** (e.g., Castillo, Red Bourbon, SL28, Castillo and Colombia Blend). Optimal moisture content is presumed to support this.
    - **Indirect Impact:** Slower bean development at high altitudes can lead to a denser cell structure, contributing to a more substantial body, enhancing the sensory experience and thus the overall quality score.
- **Processing Methods:**
    - **Trend: Double Anaerobic Washed (Castillo, 8.25)** consistently yields the highest body scores. **Honey/Mossto (Red Bourbon, 7.92)** and **Natural/Dry (SL34+Gesha, 7.92)** also produce high body. Washed/Wet (SL28, 7.92; Castillo and Colombia Blend, 7.83) can also result in good body. However, **Semi Lavado (Mundo Novo, 6.83)** yields significantly lower body.
    - **Indirect Impact:** Processing impacts the solubles in the coffee. Methods that encourage more solids (e.g., naturals, anaerobics) or manage mucilage effectively can contribute to a heavier, more viscous body.

- **Coffee Variety:**
    - **Trend for Lower Body: Castillo, Caturra, Bourbon, Caturra, Castillo, Colombia, Catuai and Mundo Novo, Maragogype, Yellow Catuai, Typica, Bourbon, Catimor, Catucai, Mundo Novo, Santander, Pacas** are consistently associated with lower body, often linked to Brazil and El Salvador.
    - **Trend for Higher Body: Castillo, Red Bourbon, SL34+Gesha, SL28, and Castillo and Colombia Blend** consistently achieve **high body scores**.
    - **Indirect Impact:** Varietal characteristics influence bean density and composition, directly impacting the perceived body.
- **Origin Country/Region:**
    - **Trend: Colombia (Castillo, Red Bourbon, Castillo and Colombia Blend)** and **Taiwan (SL34+Gesha)** consistently produce coffees with **superior body**. Brazil and El Salvador tend to have lower body in many varieties. **Kenya (SL28)** also stands out for high body using Washed/Wet.
    - **Indirect Impact:** Regional practices and environmental conditions (e.g., high altitude promoting denser beans) contribute to desirable body, which is a key component of a high-quality cup.

2.6 How does Balance get affected by different environmental and typical factors?

Influence on Balance: Balance (r=0.93) is a highly influential attribute reflecting the harmonious interplay of all sensory components (flavor, acidity, body, sweetness, etc.). A well-balanced coffee has no single attribute dominating or clashing, leading to a much higher overall quality score.

Factors and Trends:

- **Altitude and Moisture Percentage:**
    - **Trend:** Higher altitudes (1500-2500 ft) are consistently associated with **better balance** (e.g., Castillo, Red Bourbon, Wolishalo/Kurume/Dega, Geisha). Optimal moisture content facilitates the development of all attributes in harmony. Low moisture content can also support good balance (Geisha in Taiwan, 8.04).
    - **Indirect Impact:** Conditions at higher altitudes promote slow development of complex compounds that, when properly processed and dried (optimal moisture), lead to a more integrated and harmonious sensory profile, directly elevating overall quality.
- **Processing Methods:**
    - **Trend: Double Anaerobic Washed (Castillo, 8.42)** consistently produces the highest balance. **Natural/Dry (SL34+Gesha, 8.08; Geisha, 7.89-8.0)** and **Honey/Mossto (Red Bourbon, 7.92)** also yield high balance. Washed/Wet

(Wolishalo/Kurume/Dega, 7.92; Geisha in Costa Rica/Guatemala/Taiwan, 7.67-8.17) is also highly successful. Semi Lavado tends to result in poor balance (Mundo Novo, 6.83).
    - **Indirect Impact:** Processing profoundly influences how flavors, acids, and body integrate. Advanced or meticulous processing methods allow for controlled development, preventing any single attribute from overpowering others, thus creating a balanced and high-quality cup.
- **Coffee Variety:**
    - **Trend for Lower Balance:** The same varieties that score low on flavor and body (e.g., **Castillo, Caturra, Bourbon, Catuai and Mundo Novo, Maragogype, Yellow Catuai, Typica, Bourbon, Catimor, Catucai, Mundo Novo, Santander, Pacas**) tend to show **lower balance**.
    - **Trend for Higher Balance: Castillo, SL34+Gesha, Red Bourbon, Wolishalo/Kurume/Dega, and Geisha** consistently achieve **high balance scores**.
    - **Indirect Impact:** Genetic predisposition for complex and well-integrated attributes in certain varieties is key to achieving excellent balance, which is a top determinant of overall quality.
- **Origin Country/Region:**
    - **Trend: Colombia (Castillo, Red Bourbon), Taiwan (SL34+Gesha, Geisha), Ethiopia (Wolishalo/Kurume/Dega, Geisha), and**

Guatemala (Geisha) are consistently associated with **superior balance**. Brazil and El Salvador tend to show lower balance in many varieties.
    - **Indirect Impact:** Regional terroirs and the cumulative expertise in cultivation and processing contribute to the harmonious development of coffee's sensory attributes, which is the essence of balance and high overall quality.

Overall Conclusion and Strategic Recommendations

The analysis unequivocally establishes a strong hierarchical influence of sensory attributes on overall coffee quality, with **Flavor, Aftertaste, and Balance** being the most critical. These attributes, along with Acidity, Aroma, and Body, are not isolated but are profoundly shaped by a complex interplay of environmental conditions, cultivation practices, and processing methods.

Key Trends in Influences:

1. **Altitude's Consistent Positive Impact:** Higher altitudes consistently correlate with improved Acidity, Aroma, Aftertaste, Flavor, and Body, indirectly leading to higher overall quality through more complex and desirable sensory profiles.
2. **Processing Method as a Quality Amplifier:** While Washed/Wet and Natural/Dry are fundamental, specialized methods like **Double Anaerobic Washed, Honey/Mossto, and Semi Washed** consistently lead to superior scores across multiple sensory attributes,

particularly for Flavor, Aftertaste, Body, and Balance. This highlights their potential for enhancing overall quality. However, standard methods, when meticulously applied in optimal environments, also yield high quality.

3. **Varietal Specificity for Targeted Quality:** Certain coffee varieties (e.g., Geisha, Castillo, Red Bourbon, SL34+Gesha) consistently excel across all high-correlation sensory attributes, making them prime candidates for specialty coffee production. Other varieties might struggle even under optimal conditions.
4. **Moisture Percentage of Coffee Beans is Foundational:** Optimal moisture (10-12%) is crucial for preventing defects that compromise all sensory attributes. While high moisture can sometimes be mitigated by careful processing for some varieties, consistency in moisture management is vital for reliable quality.
5. **Regional Terroir as a Holistic Factor:** The origin region acts as a comprehensive influencer, integrating climate, soil, local practices, and processing expertise. Regions like Colombia, Taiwan, Ethiopia, and Guatemala consistently demonstrate environments and practices conducive to high sensory attribute scores and, consequently, high overall quality.

Strategic Recommendations for Enhancing Coffee Quality:

- **Invest in Specialized Processing:** Promote and invest in training and infrastructure for advanced processing methods (e.g., Anaerobic, Honey) in

regions aiming for top-tier quality, recognizing their strong correlation with superior Flavor, Aftertaste, and Balance.

- **Optimize Processing for Regional & Varietal Nuances:** Conduct detailed studies to identify the optimal processing method for specific varieties within distinct microclimates. Avoid a "one-size-fits-all" approach, as seen with Maragogype or Mundo Novo.
- **Prioritize High-Altitude Cultivation:** Support farming at higher altitudes where feasible, as this naturally contributes to the development of key sensory attributes.
- **Enhance Moisture Management Protocols:** Implement stringent moisture control measures at all stages of post-harvest processing to preserve delicate aromatic and flavor compounds and prevent defect formation.
- **Focus on Varietal Selection:** Encourage the cultivation of high-performing varieties (e.g., Geisha, Castillo, Red Bourbon) in suitable environments to maximize the potential for exceptional sensory profiles.
- **Promote Knowledge Transfer:** Facilitate the sharing of best practices from high-performing regions and processing methods to those struggling, focusing on how specific interventions impact Aroma, Acidity, Aftertaste, Flavor, Body, and Balance.
- **Refine Quality Evaluation:** While Uniformity, Sweetness, and Clean Cup are hygiene factors, ensure continued adherence to these baselines, as their absence would severely degrade overall quality.

> Cuppers should continue to emphasize Flavor, Aftertaste, and Balance as primary differentiators.

Q .2. Is there a correlation between processing methods, origin regions, and coffee quality scores?

Analytical Approach Used or Methodology (Visual & Interactive Components):

To explore the relationships between origin, processing method, and coffee quality, I built three primary visuals in Power BI, each accompanied by interactive slicers to allow dynamic filtering:

1. **Average Quality by Country of Origin**
    - **Visual type**: Bar chart
    - **Axis**:
        - **X-axis**: Country of origin
        - **Y-axis**: Average total quality score
    - **Purpose**: Identifies which countries consistently produce higher-scoring coffees and highlights national-level quality differences.
2. **Average Quality by Processing Method**
    - **Visual type**: Bar chart

- **Axis**:
  - **X-axis**: Processing method
  - **Y-axis**: Average total quality score
- **Purpose**: Ranks methods (e.g. Double Anaerobic, Washed/Wet, Natural/Dry) by their typical contribution to quality, revealing which techniques tend to yield superior results.

3. **Average Quality by Region**
   - **Visual type**: Bar chart
   - **Axis**:
     - **X-axis**: Region (sub-national)
     - **Y-axis**: Average total quality score
   - **Purpose**: Drills down into intra-country variation, showing how microclimates and local practices influence quality within each origin.

Interactive Slicers

- For each of the three visuals, I added slicers on the same fields (Country, Processing Method, Region), enabling users to:
  - Quickly filter all visuals simultaneously by selecting one or more countries, methods, or regions.

- Instantly observe how average quality scores shift when focusing on specific subsets of the data.

Refer to pages marked as Q.2.) for the visuals and measures used.

Answer to Q.2: Is there a correlation between processing methods, origin regions, and coffee quality scores?

Yes, there is a discernible correlation between processing methods, origin regions, and coffee quality scores. While no single processing method or region guarantees high quality across the board, the data reveals specific combinations that consistently yield higher or lower average quality scores. High-quality coffees often emerge from regions employing diverse and sometimes specialized processing methods, demonstrating that regional expertise and environmental conditions significantly influence how effectively a processing method contributes to quality. Conversely, lower-scoring coffees are also tied to specific regional-processing method combinations, highlighting areas where refinement or alternative approaches may be needed. The most impactful correlations are often seen when analyzing specific regions within countries, as microclimates and local practices can significantly influence the outcome of a given processing method.

Detailed Analysis of Correlations and Trends

The analysis of average total coffee quality points, grouped by processing method, country, and region of origin, provides insights into these correlations. The data suggests that while certain processing methods generally yield higher average scores, the specific region within a country plays a crucial role in the ultimate quality outcome, often dictating the optimal processing method for that terroir.

Overall Processing Method Performance (Average Total Points)

- **Top Performers (Generally Higher Quality):**
    - **Double Anaerobic Washed: 89.33**
    - **Semi Washed: 87.42**
    - **Honey/Mossto: 87.08**
    - **Double Carbonic Maceration / Natural: 84.75**
    - **Wet Hulling: 84.25**
    - **Anaerobico 1000h: 83.25** (Note: Despite the high average for Double Anaerobic Washed, Anaerobico 1000h is slightly lower than some standard methods).
- **Mid to Lower Performers (Standard or Mixed Quality):**
    - Natural/Dry: 83.70
    - Washed/Wet: 83.67
    - Pulped Natural/Honey: 83.55

- **Lowest Performer:**
    - Semi Lavado: 78

Initial Observation: Specialized or experimental processing methods (Double Anaerobic Washed, Semi Washed, Honey/Mossto, Double Carbonic Maceration / Natural) generally achieve higher average quality scores globally, suggesting that innovative or resource-intensive processing can yield superior results. However, their infrequent application compared to traditional methods (Washed/Wet, Natural/Dry) means these high averages might be influenced by a smaller, more carefully controlled sample size.

Correlation by Country of Origin (Average Total Points)

Countries with higher overall average scores tend to have regions and processing methods that consistently perform well.

- **Top 5 Countries by Average Quality:**
    1. **Ethiopia: 84.96**
    2. **Tanzania: 84.74**
    3. **Taiwan: 84.36**
    4. **Guatemala: 84.30**
    5. **Madagascar: 84.25** / **Uganda: 83.92** (Madagascar is based on a single record, making Uganda a more robust indicator here).

- **Bottom 5 Countries by Average Quality:**

    1. El Salvador: 81.53
    2. Brazil: 81.88
    3. Nicaragua: 82.13
    4. Peru: 82.33
    5. Mexico: 82.71

Initial Observation: There's a clear distinction in average quality scores across countries. This overall country score often reflects the predominant processing methods and specific regional strengths within that country.

In-Depth Regional and Processing Method Correlation

This section delves into specific regional performances within countries, linking them to processing methods and overall quality.

Part A: Countries Producing More Than Global Average Quality Coffee (High Quality Coffee)

1. **Ethiopia (Average: 84.96 points)**

    - **Correlation:** Ethiopia's high average is driven by a mix of Natural/Dry and Washed/Wet methods across its top regions.
    - **Key Trend:** Regions like **Guji (86.21) and Southern Ethiopia Guji (85.33) excel with**

Natural/Dry processing, confirming this method's potential for high quality in ideal Ethiopian conditions. Concurrently, **Gedeb, Yirgacheffe, Sidamo (86.08) and Oromia (84.69) achieve high scores with Washed/Wet processing**, highlighting the country's dual expertise.

- **Insight:** Ethiopia exemplifies that both Natural/Dry and Washed/Wet methods, when executed well within specific regional terroirs, can produce exceptional quality. The strong regional identity (Guji, Yirgacheffe) appears to be a more dominant factor than a single processing method.

2. **Taiwan (Average: 84.36 points)**

    - **Correlation:** Taiwan's high quality is significantly correlated with a prevalence of **Natural/Dry processing** in its top-scoring regions.
    - **Key Trend: Shibi, Gukeng Township, Yunlin County (86.08), Gukeng Township, Yunlin County (85.92), and Zhuo Xi Township (85.67) all achieve their highest scores with Natural/Dry processing**. This indicates Taiwan's strong mastery of natural processing, leveraging its climate for excellent drying.
    - **Mixed Methods, High Quality:** Chiayi notably shows high quality across Natural/Dry (85.43),

Washed/Wet (85.74), and Pulped Natural/Honey (86.08), suggesting a diverse capability in quality processing.
    - **Insight:** Taiwan showcases how a region can master a specific processing method (Natural/Dry) to achieve consistent high quality, but also demonstrates the potential for other methods to excel when applied skillfully within conducive microclimates (e.g., Chiayi).
3. **United Republic of Tanzania (Average: 84.74 points)**

    - **Correlation:** All top regions (**Arusha (84.92), Kilimanjaro (84.58), Mbeya (84.83)**) consistently apply the **Washed/Wet method**.
    - **Key Trend:** Tanzania's high average is uniformly linked to proficient Washed/Wet processing across its primary coffee-growing regions.
    - **Insight:** This suggests a standardized and effective approach to Washed/Wet processing across key Tanzanian coffee regions, contributing to consistently high quality.
4. **Guatemala (Average: 84.30 points)**

    - **Correlation:** Quality in Guatemala is correlated with a significant utilization of **Washed/Wet processing** across most of its higher-quality

regions, alongside successful **Natural/Dry** implementations.
    - **Key Trend:** Regions like Huehuetenango (Washed: 84.50), Antigua, Sierra de las Minas, Atitlan predominantly use Washed/Wet. However, Acatenango and other regions also show success with Natural/Dry processing.
    - **Insight:** Guatemala, similar to Ethiopia, demonstrates that both Washed/Wet and Natural/Dry methods can yield high quality depending on the specific regional expertise and microclimates. The high concentration of quality in regions that predominantly use Washed/Wet method points to its established success and widespread adoption for specialty coffee production.
5. **Indonesia (Average: 84.25 points) & Madagascar (Average: 84.25 points)**

    - **Correlation:** These countries have single data points for high quality.
    - **Key Trend:** Indonesia's high score comes from **Lintong Nihuta / Dolok Sanggul, Sumatera Utara using Wet Hulling**. Madagascar's comes from **Itasy using Washed/Wet**.
    - **Insight:** While limited data, it highlights that even less common processing methods (Wet Hulling) or single-origin efforts can achieve high

quality when expertly executed within a specific region.

6. **Uganda (Average: 83.92 points)**

    - **Correlation:** Both top regions, **Rwenzori (84.17) and Mt Elgon (83.42), exclusively use Washed/Wet processing**.
    - **Key Trend:** Uganda's quality is predominantly linked to effective Washed/Wet processing, indicating a focused and successful approach for specialty coffee.
    - **Insight:** Reinforces the pattern seen in Tanzania: a consistent, well-executed Washed/Wet method can be a strong predictor of quality in certain origins.

Part B: Countries Producing Less Than Global Average Quality Coffee (Mediocre or Poor Quality Coffee Producing States)

1. **Colombia (Average: 83.78 points)**

    - **Correlation:** While overall below average, Colombia exhibits strong regional variations. Its highest quality is strongly correlated with **specialized processing methods**.
    - **Key Trend: Piendamo Cauca (89.33) excels with Double Anaerobic Washed**, and **Popayan, Cauca (87.08) with Honey/Mossto**.

This suggests that while standard Washed/Wet (dominant in many Colombian regions) might keep the average down, targeted use of advanced methods can significantly elevate quality.
    - **Insight:** Colombia's data highlights that simply being a major coffee producer doesn't guarantee high overall average quality, but innovative processing at a regional level can lead to exceptional results, even when the country's average is relatively moderate. This suggests a need for wider adoption or refinement of these advanced methods.
2. **Costa Rica (Average: 83.74 points)**

    - **Correlation:** Primarily uses **Washed/Wet processing**, but with varying degrees of success across regions.
    - **Key Trend: Los Santos Tarrazú (85.84) stands out with Washed/Wet**, indicating that this method can produce high quality within a well-regarded region. However, other Washed/Wet regions like Occidente (81.58) and Corralillo Tarazzu (82.00) pull the average down.
    - **Insight:** This suggests that while Washed/Wet is the dominant method, regional microclimates, altitude, and farmer practices within Costa Rica significantly impact the final

quality. Tarrazú's reputation for quality is upheld even with a common processing method due to superior execution and ideal growing conditions.

3. **Laos (Average: 83.39 points)**
    - **Correlation:** Diverse processing methods yield varied quality.
    - **Key Trend: Laos Borofen Plateau (87.42) with Semi Washed** is the outlier for high quality. Nongluang Bolaven Plateau (83.08) uses Natural/Dry, while Bolaven Plateau (79.67) uses Washed/Wet, scoring lowest.
    - **Insight:** Semi Washed appears to be a promising method for Laos in specific regions, significantly outperforming its Natural/Dry and Washed/Wet counterparts, indicating a strong correlation between this processing method and higher quality for this origin.
4. **Honduras (Average: 83.28 points)**
    - **Correlation:** Quality varies widely across regions and processing methods.
    - **Key Trend: Centro, Lagu Lentillas-Ajuterique, Comayagua (84.34) uses Washed/Wet** to achieve its highest quality, while **San Andres, Lempira (84) uses Pulped Natural/Honey**. San Jose La Paz (83.67) uses Natural/Dry.

- **Insight:** Honduras demonstrates that diverse processing methods can all contribute to quality, but effective execution at the regional level is key. No single method is universally superior across its regions.

5. **Vietnam (Average: 82.89 points)**

    - **Correlation:** Exhibits a mix of processing methods with a generally lower average quality.
    - **Key Trend: Quang Tri (84.58) stands out with Natural/Dry**, indicating potential for this method in specific regions. However, other regions using Pulped Natural/Honey (Lam Dong Province, 81.83) or Washed/Wet (Dalat, 82.33) score lower.
    - **Insight:** Vietnam shows that while a specific region can excel with a particular method (Natural/Dry in Quang Tri), widespread challenges or less optimized processing in other areas (Lam Dong, Dalat) can pull down the national average.

6. **Thailand (Average: 82.83 points)**

    - **Correlation:** Shows varied quality across regions and methods.
    - **Key Trend: Chiang Mai (84.17) shows highest quality with Pulped Natural/Honey (85.67)**, outperforming its Natural/Dry

counterpart in the same region. Nan (83.92) excels with Natural/Dry.
    - **Insight:** While a leader in defect occurrences, Thailand still produces some higher-quality coffees, showing regional pockets of excellence. The success of Pulped Natural/Honey in Chiang Mai suggests regional expertise in this method.
7. **Brazil (Average: 81.54 points) & El Salvador (Average: 81.53 points)**

    - **Correlation:** These countries consistently have lower average quality scores, even with diverse processing methods.
    - **Key Trend:**
        - **Brazil: Campo das Vertentes (84.75) with Double Carbonic Maceration/Natural** is a clear outlier, significantly higher than other regions predominantly using Natural/Dry or Pulped Natural/Honey. **Minas Gerais (78) using Semi Lavado** is the lowest.
        - **El Salvador: Chalatenango (84.33) with Pulped Natural/Honey** performs significantly better than regions using Natural/Dry, especially Volcan de San Vicente (78.08).
    - **Insight:** These countries, despite their large production volumes, often struggle with

consistently high quality. However, they demonstrate that even within a lower-average country, **specific regions can achieve excellent quality through the adoption of more controlled or innovative processing methods**. This highlights the importance of localized excellence in elevating overall quality perception.

Common Trends and Overarching Insights:

1. **Regional Nuance is Paramount:** The most significant correlation is found not just between a processing method and quality, but between a processing method *within a specific region*. Microclimates, soil conditions, and local expertise dictate which processing method will perform optimally. For example, Natural/Dry excels in Taiwan's Gukeng and Ethiopia's Guji, while Washed/Wet shines in Tanzania and Uganda.
2. **Specialized Processing Methods Often Yield Higher Scores:** Methods like Double Anaerobic Washed, Semi Washed, Honey/Mossto, and Double Carbonic Maceration consistently appear at the top of the quality spectrum when employed successfully. This suggests that the extra investment and control required for these methods pay off in terms of higher quality scores, albeit often in smaller, highly controlled batches.

3. **Washed/Wet and Natural/Dry are Versatile but Variable:** These foundational methods are ubiquitous. Their correlation with quality is highly dependent on the origin region and the meticulousness of their application. They can produce exceptional results (e.g., Washed/Wet in Tanzania/Uganda, Natural/Dry in Taiwan/Ethiopia) or contribute to lower averages if not optimally managed (e.g., certain regions in Costa Rica, Honduras, Vietnam, Brazil).
4. **Country Average Can Be Misleading:** A country's overall average quality score doesn't tell the full story. Within countries with moderate or low averages (e.g., Colombia, Brazil, El Salvador), there are often specific regions that achieve remarkably high scores by adopting specialized or well-executed processing methods. This suggests pockets of excellence.
5. **Correlation, Not Causation:** While a correlation exists, it's crucial to remember that quality is multifaceted. Ideal growing conditions (altitude, climate, soil), varietal selection, careful harvesting, and post-harvest handling all interact with the chosen processing method and regional expertise to determine the final coffee quality score.

Conclusion to Q.2:

The correlation between processing methods, origin regions, and coffee quality scores is strong and highly

interdependent. High-quality coffee is not merely a result of a specific processing method but rather a synergistic outcome of **matching the right processing method to the unique characteristics of an origin region**, coupled with rigorous execution and local expertise. Regions that consistently achieve high scores often demonstrate a mastery of one or more processing methods that are particularly suited to their environmental conditions and coffee varieties. This report emphasizes that detailed, regional-level analysis is critical to understanding and improving coffee quality, as broad generalizations based solely on country averages or processing methods can overlook crucial nuances.

Q.3.)Can we identify any trends or patterns in defect occurrences and their impact on overall coffee quality?

This response analyzes trends and patterns in coffee defect occurrences—specifically Category 1 (severe defects) and Category 2 (less severe defects)—and their impact on overall coffee quality. Defect counts are normalized to "defects per tonne" to enable fair comparisons across varying production volumes. The analysis examines influences from regions, seasons, coffee varieties, altitudes, moisture content, and processing methods, aiming to identify actionable insights for quality improvement.

Part 1:

Category 1 Defect Occurrences and Their Impact on Overall Coffee Quality Answer:

Yes, clear trends and patterns in Category 1 defect occurrences are identifiable, showing strong regional and seasonal influences tied to microclimates, harvest timings, and processing methods. These defects predominantly have a negative impact on coffee quality, with strong inverse correlations in most cases (higher defect rates linked to lower quality), though exceptions exist where defects may enhance quality in specific contexts.

Detailed Analysis of Category 1 Defect Trends Category 1 defects, which severely affect coffee quality, vary significantly by country, driven by environmental and processing factors:

Thailand (1,500 defects/tonne) Trend: Highest global rate, peaking in July in North Thailand due to monsoon moisture. Varieties: Java, Caturra (negative quality correlation under high moisture). Processing: Washed/Wet (negative correlation). Impact: Strong inverse correlation (e.g., Caturra, $r = -0.98$), indicating severe quality degradation. Insight: Moisture control during the wet season is critical. Hawaii (41.11 defects/tonne) Trend: Peaks in November in Kau and Kona Districts during harvest, influenced by microclimates. Varieties: Catuai, Typica (strong negative correlation, $r = -0.87$). Processing: Washed/Wet. Impact: Significant quality reduction. Insight: Localized conditions and harvest timing amplify defects. Mexico (1.33 defects/tonne) Trend: Peaks in August (Veracruz) and April (Chiapas) due to staggered harvests. Varieties: Typica, Sarchimor, Bourbon (strong negative correlation, $r = -1$ in August). Processing: Washed/Wet. Impact: Severe quality impact during peak months. Insight: Harvest pressure

affects quality despite optimal moisture. Nicaragua (0.56 defects/tonne) Trend: Peaks in June (Esteli) and January (Matagalpa). Varieties: SHG, Catrenic (positive correlation, $r = 0.73$). Processing: Natural/Dry (strong positive correlation, $r = 0.96$). Impact: Defects enhance quality, uniquely. Insight: Natural processing may produce desirable “defects.” Colombia (0.10 defects/tonne) Trend: Peaks in February in Cauca. Varieties: Caturra (positive correlation, $r = 0.37$). Processing: Washed/Wet. Impact: Minimal quality reduction, possible enhancement. Insight: Defects may align with quality attributes. Costa Rica (0.07 defects/tonne) Trend: Peaks in March in Corralillo Tarrazú during dry-season harvest. Varieties: Caturra (negative correlation, $r = -0.47$). Processing: Washed/Wet. Impact: Quality reduction despite low rates. Insight: Overexposure during drying may contribute. Ethiopia (0.06 defects/tonne) Trend: Peaks in November in Sidama during harvest. Varieties: Ethiopian Heirlooms (negative correlation, $r = -0.30$). Processing: Washed/Wet. Impact: Slight quality reduction. Insight: Early rains during sun-drying increase defects. Summary Key Trends: Highest rates in Thailand; peaks align with harvest and moisture events. Varieties: Caturra and Typica are most affected, typically negatively. Processing: Washed/Wet often linked to negative quality, except in Nicaragua (Natural/Dry, positive). Recommendation: Target moisture management and processing adjustments in high-risk regions. Part 2: Category 2 Defect Occurrences and Their Impact on Overall Coffee Quality Answer: Yes, significant trends and patterns in Category 2 defect occurrences are evident, showing regional, seasonal, and varietal influences. These

defects generally negatively impact coffee quality, with strong inverse correlations (higher rates, lower quality), though rare positive correlations suggest context-specific benefits.

Detailed Analysis of Category 2 Defect Trends Category 2 defects, less severe but still impactful, show broader occurrence with distinct patterns:

Thailand (13,667 defects/tonne) Trend: Highest globally, peaking July–November across regions. Varieties: Typica, Catimor, Java (Java, $r = -1$; Catimor, $r = 0.84$). Impact: Predominantly negative, except Catimor. Insight: Monsoon moisture drives widespread defects. El Salvador (13,507 defects/tonne) Trend: Peaks in March, November, February. Varieties: Maragogype, Bourbon (strong negative correlation, $r = -0.99$). Processing: Natural/Dry. Impact: Severe quality degradation. Insight: Processing challenges amplify defects. Vietnam (4,003 defects/tonne) Trend: Peaks in April, June. Varieties: Catimor (negative correlation, $r = -1$ with Pulped Natural). Processing: Pulped Natural/Honey. Impact: Significant quality loss. Insight: Processing method exacerbates defects. Taiwan (654.96 defects/tonne) Trend: Peaks in January, October, November. Varieties: Typica ($r = -0.89$), Gesha; some regions positive ($r = 1$). Processing: Natural/Dry, Washed/Wet. Impact: Mixed, mostly negative. Insight: Regional and varietal variability. Colombia (628.83 defects/tonne) Trend: Persistent from March to December. Varieties: Typica Gesha, Castillo (strong negative correlation, $r = -1$). Impact: Severe quality impact. Insight: Broad harvest issues. Hawaii (192 defects/tonne) Trend:

Peaks in November. Varieties: Typica, Catuai. Processing: Washed/Wet. Impact: Likely negative. Insight: Harvest timing drives defects. Ethiopia (57.31 defects/tonne) Trend: Spread across months, Sidama notable. Varieties: Heirlooms (Natural/Dry, $r = 0.85$; Washed/Wet, $r = -0.33$). Impact: Mixed, Sidama negative ($r = -1$). Insight: Processing influences impact. Summary Key Trends: Highest rates in Thailand, El Salvador; seasonal peaks tied to harvest/rain. Varieties: Typica, Caturra, Catimor frequently affected. Processing: Varies (e.g., Pulped Natural in Vietnam, Natural/Dry in El Salvador). Recommendation: Optimize processing and harvest management. Part 3: Overall Trends, Patterns, and Common Insights Across Defect Categories Answer: Yes, robust trends and patterns are identifiable across Category 1 and Category 2 defects, showing a significant, mostly negative impact on coffee quality. Common drivers include regional/seasonal factors, processing methods, and varietal susceptibility, with rare positive correlations suggesting nuanced quality contributions.

Detailed Analysis of Common Insights Regional and Seasonal Patterns Trend: Thailand (both categories, July), Hawaii (November), Mexico (August/April) show consistent defect peaks tied to harvest and moisture. Insight: Environmental factors and harvest timing are universal drivers. Processing Influence Trend: Washed/Wet linked to defects in Thailand, Hawaii, Mexico; Natural/Dry varies (positive in Nicaragua Category 1, negative in El Salvador Category 2). Insight: Processing requires context-specific optimization. Varietal Susceptibility Trend: Caturra

(Thailand, Costa Rica) and Typica (Hawaii, Mexico) consistently vulnerable; some (e.g., Nicaragua SHG, Ethiopia Heirlooms) show positive correlations. Insight: Varietal-specific strategies are needed. Quality Impact Nuances Trend: Predominantly negative (e.g., Thailand, El Salvador), but positive in Nicaragua (Category 1), Colombia (Category 1), Ethiopia (Category 2 Natural). Insight: Some “defects” may enhance quality, warranting redefinition. Moisture as a Driver Trend: High moisture increases defects (Thailand); optimal moisture insufficient alone (Mexico). Insight: Comprehensive moisture management is essential. Conclusion and Recommendations Key Drivers: Moisture, harvest timing, and processing dominate defect trends. Actionable Steps: Enhance moisture control (e.g., drying tech in Thailand). Tailor processing to regions/varieties (e.g., explore Natural/Dry benefits). Reassess “defect” definitions where quality improves.

Q.4.)How do different variables interact to influence the Total Cup Points, which represent an overall measure of coffee quality?

Answer: The Total Cup Points, a composite score reflecting coffee quality, are shaped by the interplay of sensory attributes, environmental factors, processing methods, coffee varieties, regions, and defects. This analysis provides a concise, data-driven explanation of how these variables interact to influence Total Cup Points, emphasizing the dominant sensory attributes—Flavor (r=0.94), Balance (r=0.93), and Aftertaste (r=0.93)—and their modulation by external factors.

Sensory Attributes Driving Total Cup Points

Sensory attributes are the primary determinants of Total Cup Points, with the following Pearson correlation coefficients indicating their relative influence:

Attribute	Correlation (r)	Approx. Effect per Unit Increase
Flavor	0.94	+1.8 points
Balance	0.93	+1.6 points
Aftertaste	0.93	+1.5 points
Acidity	0.90	+1.2 points
Aroma	0.87	+1.0 point
Body	0.85	+0.9 point
Uniformity	~0.00	Baseline (hygiene factor)
Sweetness	~0.00	Baseline (hygiene factor)
Clean Cup	~0.00	Baseline (hygiene factor)

Insight: Flavor, Balance, and Aftertaste are the core drivers, contributing significantly to quality scores, while Acidity, Aroma, and Body provide substantial support. Uniformity, Sweetness, and Clean Cup are prerequisites, showing

minimal variation and thus negligible direct impact on quality differentiation.

Key Interactions Shaping Sensory Attributes

The sensory attributes are modulated by environmental factors, processing methods, varieties, regions, and defects, with the following interactions being most critical:

1. Moisture × Altitude

- **Optimal Moisture (10–12%) at 1000–2500 ft**: Enhances Flavor (+1.7 points), Acidity, and Aftertaste due to controlled drying and flavor development. Example: Geisha in Taiwan at 1000–1500 ft scores 8.17 in Flavor with Natural/Dry processing.
- **High Moisture (>12%) at <1000 ft**: Increases defect risk, reducing Flavor (−1.0 point) and Aftertaste. Example: Maragogype in El Salvador at 500–1000 ft scores 6.75 in Flavor.
- **Low Moisture (<10%)**: Can lead to over-drying, slightly reducing Body and Balance, as seen in some Thai Catimor samples.

2. Processing Method × Region

Processing methods amplify or diminish sensory attributes based on regional terroir and expertise:

Region	Top Method	ΔTotal Cup Points vs. Baseline	Key Sensory Boost

Colombia	Double Anaerobic Washed	+2.5	Flavor (8.50), Balance (8.42)
Ethiopia	Washed/Wet	+1.8	Acidity (8.17), Aftertaste
Taiwan	Natural/Dry	+2.0	Aroma (8.25), Flavor (8.17)
Brazil	Natural/Dry	+1.2	Body (7.67), Flavor (7.58)
El Salvador	Honey/Mossto	+0.8	Balance, Aftertaste

Insight: Specialized methods like Double Anaerobic Washed in Colombia maximize Flavor and Balance, while Natural/Dry in Taiwan enhances Aroma. Regional expertise ensures method efficacy, e.g., Ethiopia's mastery of Washed/Wet boosts Acidity.

3. Variety × Processing Method

Varietal genetics interact with processing to shape sensory outcomes:

- **Castillo + Double Anaerobic Washed**: Achieves high Balance (8.42) and Flavor (8.50) in Colombia at 1500–2000 ft, leveraging anaerobic fermentation for complexity.
- **SL34+Geisha + Natural/Dry**: Scores >8.1 in Aroma and Flavor in Taiwan, emphasizing floral notes through natural processing.

- **Maragogype + Natural/Dry**: Poor match, yielding low Flavor (6.75) in El Salvador at 1000–1500 ft due to suboptimal drying conditions.
- **Red Bourbon + Honey/Mossto**: Enhances Balance (7.92) and Flavor (8.33) in Colombia at 2000–2500 ft, balancing sweetness and acidity.

Insight: High-potential varieties (Geisha, Castillo) excel with tailored processing, while mismatches (e.g., Maragogype with Natural/Dry) depress scores.

4. Defect Rate × Processing Method

- **Overall Impact**: Defect rate correlates negatively with Total Cup Points ($r=-0.65$), reducing Flavor, Aftertaste, and Balance.
- **Regional Variations**:
  - *Thailand*: High Category 1 defects (1500/tonne) in Washed/Wet lots during monsoon (July) severely lower quality ($r=-0.98$ for Caturra).
  - *Nicaragua*: Natural/Dry lots show a slight positive correlation ($r=+0.10$), where minor defects add perceived complexity to Flavor.
- **Category 2 Defects**: More prevalent (e.g., 13,667/tonne in Thailand), with strong negative correlations ($r=-0.99$ in El Salvador for Maragogype), impacting Aftertaste and Body.

Insight: Defect management is critical, but controlled "defects" in natural processing can enhance complexity in specific contexts.

5. Quaker Count × Variety

- **Overall Correlation**: Quakers correlate negatively with quality (r=−0.42), particularly in El Salvador (r=−0.91, 15,000/tonne).
- **Varietal Effects**:
    - *Maragogype*: High quaker count (6000/tonne) in El Salvador depresses Flavor (6.75) and Aftertaste.
    - *SL28*: Robust structure mitigates ~50% of quaker impact, maintaining higher Balance scores in Kenya.
    - *Yellow Bourbon*: Positive correlation (r=1) in Brazil with low quakers (5.56/tonne), suggesting minimal impact on quality.

Insight: Quaker impact varies by variety, with robust varieties better resisting quality degradation.

Narrative Synthesis

Flavor, Balance, and Aftertaste drive Total Cup Points, but their expression hinges on optimizing moisture (10–12%), altitude (1000–2500 ft), and processing method. For instance, Castillo in Colombia with Double Anaerobic Washed at 1500–2000 ft boosts Total Cup Points by 2.5, while Maragogype in El Salvador with Natural/Dry at 1000–1500 ft loses over a point in Flavor due to poor drying and high quakers. Defects and quakers generally erode scores, but in niche cases (e.g., Nicaraguan naturals), minor flaws enhance complexity. Regional terroir and varietal genetics further modulate outcomes, with Ethiopia’s Washed/Wet and Taiwan’s Natural/Dry exemplifying optimal alignments.

Strategic Recommendations

1. **Optimize Variety-Processing Pairings**: Use Geisha with Natural/Dry in Taiwan, Castillo with Double Anaerobic in Colombia to maximize Flavor and Balance.
2. **Maintain Optimal Moisture (10–12%)**: Invest in drying infrastructure to prevent defects, especially at 1000–2500 ft.
3. **Prioritize Mid-High Altitudes**: Source from 1000–2500 ft to enhance Acidity, Flavor, and Aftertaste.
4. **Tailor Defect Management**: Strictly control defects in Washed/Wet lots; allow controlled complexity in Natural/Dry lots where beneficial.
5. **Leverage Regional Expertise**: Partner with regions like Ethiopia (Washed/Wet) and Colombia (anaerobic methods) for consistent high scores.
6. **Data-Driven Calibration**: Use multivariate models to predict Total Cup Points for new lots, refining sourcing and processing decisions.

Conclusion

Total Cup Points are a product of sensory attributes led by Flavor, Balance, and Aftertaste, modulated by intricate interactions among moisture, altitude, processing, variety, region, and defects. Strategic alignment of these factors—e.g., Geisha with Natural/Dry in Taiwan or Castillo with anaerobic processing in Colombia—can significantly elevate quality, while mismatches or poor defect control depress scores. By leveraging data-driven insights and regional expertise, producers can optimize coffee quality effectively.