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Data-driven analysis of farmer profiles and agricultural practices: Understanding *kapeng barako* production and farm diversification in San Jose and Nasugbu, Batangas

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ABSTRACT

This study examined factors affecting yield and profitability in *kapeng barako* coffee farming in Batangas, Philippines, focusing on the roles of farming practices, infrastructure, and farmer demographics. Using a mixed-methods approach with face-to-face interviews and farm visits, data were collected from 19 farmers across San Jose and Nasugbu, Batangas. Key variables included farmer experience, gender, farm size, production methods, and access to infrastructure such as warehousing and delivery facilities. Correlation analysis revealed that mixed-crop farming (r = 0.64), farming experience (r = 0.45), and infrastructure access (r = 0.75) positively influenced both yield and profitability of *kapeng barako* coffee in Batangas. Larger land areas correlated with higher yields (r = 0.53) but not profitability, suggesting that small farms (1-3 ha) with infrastructure access were more financially efficient. Gender was shown to have minimal correlation (-0.12) with production type, indicating equitable engagement across genders in farming practices. The study highlighted the significance of experience, land use, and infrastructure in enhancing *kapeng barako* farming profitability. Findings suggested that investment in facilities such as warehouses and support for younger farmers could boost sustainability in the region. Future research could explore these factors across broader areas to deepen understanding of the variables affecting *kapeng barako* production.

Keywords: *kapeng barako*, farming practices, profitability, agricultural infrastructure, mixed-crop farming

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1. Introduction

Coffea liberica, commonly known as *kapeng barako*, is a tropical coffee species that thrives in warm, humid climates, typically found in lowland to lower montane rainforests or open scrubland. It is primarily cultivated at elevations between 400 and 600 m but can also grow well at altitudes up to 1,200 m. This species prefers climates with average temperatures ranging from 27 °C to 30 °C and requires annual rainfall of 1,500 to 2,500 mm for optimal growth [1]. *Kapeng barako* is a beloved beverage in the Philippines and is particularly renowned in the Batangas province, where its abundant production has made it a notable local product.

Agricultural productivity is influenced by a multitude of factors, including farmer demographics, farm management practices, and land use strategies. Analyzing these variables can yield valuable insights for optimizing farming operations and promoting sustainability. In particular, understanding the dynamics of *kapeng barako* production in Batangas requires a close examination of how farmer characteristics-such as age, gender, and experience-interact with farm-related factors like land ownership and crop production techniques. This understanding is crucial for identifying opportunities for growth and improving agricultural outcomes. Coffee farming, especially the cultivation of *kapeng barako*, is vital to the rural economies of the Philippines, with Batangas serving as a key province for this unique coffee variety renowned for its bold flavor. However, smallholder farmers encounter significant challenges, including market volatility, inadequate infrastructure, and constraints in resource management. This study aims to explore how these diverse factors-including farmer characteristics, production methods, and access to facilities-affect yield and profitability, ultimately contributing to the enhancement of agricultural practices in the region.

Farmer demographics are critical in influencing management decisions. Age and years of experience impact the adoption of innovative techniques and diversification practices. Older and more experienced farmers tend to have a better understanding of farming complexities and are more likely to implement advanced methods [2]. However, younger farmers, while potentially more open to adopting modern technologies, often lack the resources or access to credit needed to scale their operations [3]. Gender also plays a significant role in farming, as women are often involved in agricultural work but may have less access to land, training, and technology compared to men, resulting in disparities in productivity [4].

Farm size and production type further shape farming outcomes. Smallholder farmers often face limitations in terms of land area, which restricts their ability to diversify or adopt mixed farming practices. As noted by [5], farmers with larger

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landholdings tend to have better opportunities for integrating crop and livestock production, leading to more sustainable agricultural systems. Diversified farms are better equipped to manage risks, improve soil health, and stabilize income streams, especially in volatile markets [6]. For *kapeng barako* farmers, due to low income from coffee farming and challenges such as climate change, many farmers are considering multi-cropping or abandoning coffee cultivation altogether, which depends heavily on land availability and market access [7].

Data-driven methods have transformed agricultural research by offering ways to analyze large datasets that capture multiple variables, including farmer demographics and production strategies. These analytical techniques allow for the identification of patterns and correlations that may not be obvious through traditional means [8]. By leveraging data on land ownership, crop production types, and demographic factors, researchers can better understand the factors that drive productivity and sustainability in farming systems. Such insights are particularly valuable in province like Batangas, where niche products like *kapeng barako* are both culturally significant and economically viable.

This study analyzes the relationships between farmer demographics, farm practices, and production types in San Jose and Nasugbu, Batangas. By examining key variables such as age, experience, land area, and production strategies, this research provides insights into the factors that influence farming decisions and outcomes. The results of this analysis can help guide policymakers and agricultural stakeholders in developing targeted interventions to improve productivity and sustainability among *kapeng barako* farmers.

2. Materials and methods

2.1. Study design

This study employed a qualitative-quantitative approach through face-to-face interviews and site visits with coffee farmers. The aim was to explore the dynamics between farmer characteristics, farm management practices, and production outcomes, particularly focusing on *kapeng barako* in San Jose and Nasugbu, Batangas.

2.2. Study sites

The research was conducted in the municipalities of San Jose and Nasugbu in Batangas, known for their coffee-growing communities. These areas were chosen due to their historical involvement in the production of *kapeng barako.*

2.3. Data collection

Data were collected from 19 farmers involved in either *kapeng barako* monoculture or mixed-crop production. The survey respondents were identified with the assistance of the Provincial Agricultural Office. However, the COVID-19 pandemic posed significant challenges to the participant availability due to the implementation of quarantine measures, social distancing protocols, travel restrictions, and other related factors, which limited the sample size and presented a major research limitation. The data collection process involved two key activities: Face-to-Face interviews and farm visits.

2.3.1. Face-to-face interviews

Interviews were conducted with individual farmers to collect personal and farm-related information. These interviews provided qualitative insights into farming experiences, challenges, and practices. The survey instruments were developed in collaboration with partner universities under the Building Research and Innovation Developmental Goals for Engineering SUCs (BRIDGES) program, including Cavite State University (CvSU), Central Mindanao University (CMU), Eastern Samar State University (ESSU), Laguna State Polytechnic University (LSPU), Mindoro State University (MinSU), Romblon State University (RSU), and Tarlac Agricultural University (TAU).

2.3.2. Farm visits

Site visits were conducted to observe farm conditions and validate the reported farming practices, infrastructure, and resources. These visits also allowed the researchers to engage with farmers directly in their work environment.

2.4. Dataset description

The collected dataset included both personal and farm-level variables. These variables were classified as follows:

2.4.1. Farmer information

The structured survey gathered demographic and experience-related information about the farmers. Specifically, it inquired about the farmer's age, years of farming experience, and gender. Three categories were used to classify farming experience: novice (0–5 years), intermediate (6–15 years), and veteran (16+ years).

2.4.2. Farm information

Detailed farm information which includes land area, production type, and access to facilities was collected. The survey contained particular questions that distinguish the land area between owned and rented, the production type which differs between farms that produce only *kapeng barako* and those that produce a variety of crops. On the other hand, questions used to assess access to facilities were focused on the availability of essential infrastructure, such as delivery trucks and warehouses.

2.4.3. Production outcome

The survey meticulously gathered data on the production outcomes of farms, focusing on *kapeng barako* yield and profitability status over the five years from 2017 to 2021.

Crop yield is a common metric that measures the amount of agricultural production harvested per unit of land area. Profitability, on the other hand, refers to the difference between the value of the farm goods produced and the costs incurred in utilizing the resources required for their production.

2.5. Data analysis

A correlation matrix was generated to identify potential relationships between the collected variables. The strength and direction of associations were measured using the Pearson correlation coefficient. This statistical method was chosen due to its effectiveness in assessing linear relationships between numerical and categorical variables, such as the impact of farming experience on productivity or land ownership on profitability.

All analyses were performed using appropriate statistical software, ensuring the accuracy and reliability of the results.

3. Results and discussion

The dataset of *kapeng barako* farmers in San Jose and Nasugbu, Batangas, reveals key trends in farmer demographics, experience levels, land use, yield production, profitability, and infrastructure influence. The sample consists of 19 farmers, mostly male, aged 33 to 77. Most are classified as Veteran farmers with over 15 years of experience, indicating that *kapeng barako* farming has a high retention rate among experienced individuals. This experience distribution suggests a need for targeted support for younger farmers to ensure the sustainability of *kapeng barako* cultivation in the region. Additionally, mixed production was the standard among these farmers, where they combined *kapeng barako* with other agricultural products, likely as a risk mitigation strategy against market and crop fluctuations.

The scatter plot shown in Figure 1 depicts the relationship between farmer age and *kapeng barako* yield production, with data points color-coded by production type. The color gradient on the right distinguishes between two production types: red for *kapeng barako*-only (coded as "0") and blue for mixed production (coded as "1").

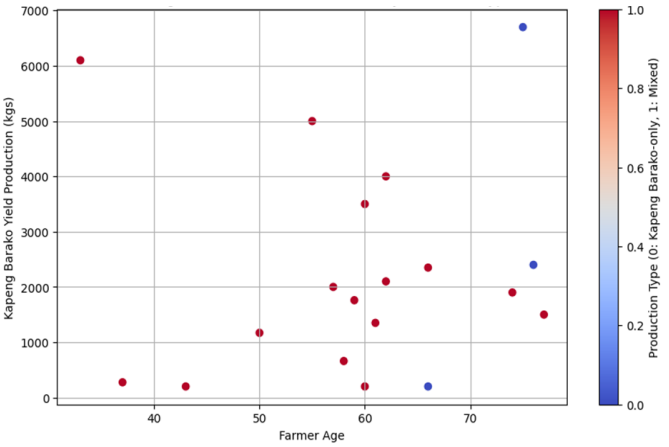

Figure 1. Farmer age vs production yield (Colored by production type).

From the plot, there is no clear trend between farmer age and yield production. High yields (above 4000 kg) are observed across various age groups, particularly among farmers in their 40s and 60s, suggesting that age alone may not be a significant factor in determining yield. Most farmers represented in the dataset produce *kapeng barako*-only (red points), with only a few instances of mixed production (blue points). The mixed production points do not show a noticeable difference in yield compared to *kapeng barako*-only production. The plot suggests that farmer age does not have a strong influence on *kapeng barako* yield, as high and low yields are observed across different age groups and production types. This implies that factors other than farmer age, such as farming techniques, land management, or environmental conditions, may play a more substantial role in determining yield.

Figure 2, displays the relationship between the total land area (in ha) used for *kapeng barako* cultivation and the resulting yield production (in kg), with profitability indicated by color. The color gradient on the right ranges from purple (indicating non-profitable, or "0") to yellow (indicating profitable, or "1").

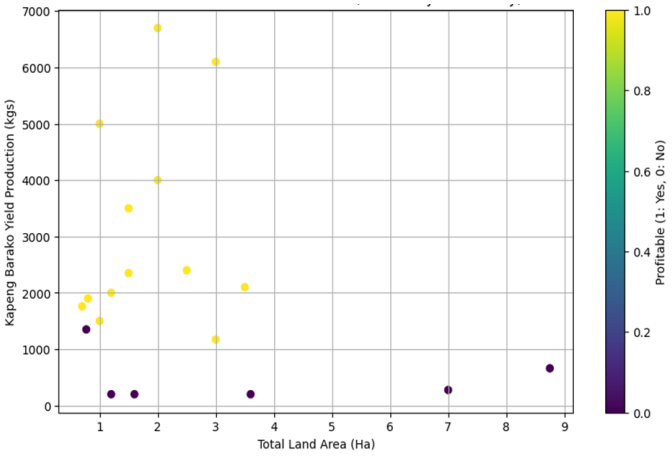

Figure 2. Total land area vs yield production and profitability (2017-2021; Colored by profitability).

From the graph, it is evident that most of the profitable data points (yellow) are clustered in the lower land area range, primarily between 1 and 3 ha, with some high-yield outliers achieving up to 7000 kg. In contrast, data points representing larger land areas (above 5 ha) tend to have lower yields and are mostly non-profitable (purple). This suggests that higher yields and profitability are more likely to occur within smaller land areas, while larger land areas are associated with lower yields and reduced profitability.

Crop yield is a standard measurement of the amount of agricultural production harvested per unit of land area. Profitability is the difference between the value of farm goods produced and the cost of the resources used in the production of those farm goods. Figure 3 indicates the relationship between warehouse facilities and profitability. Farms with warehouse facilities appear more likely to be profitable, showing that infrastructure may positively impact economic outcomes. On the other hand, Figure 4 shows the average yield by experience category (Novice, Intermediate, Veteran). Veteran farmers have slightly lower average yields, possibly due to factors other than experience alone, suggesting that other resources or practices could be impacting yield.

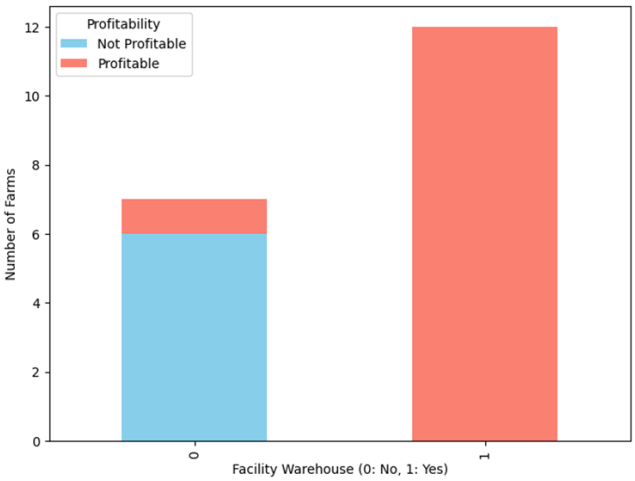

Figure 3. Profitability of the farms (2017-2021) vs facility warehouse.

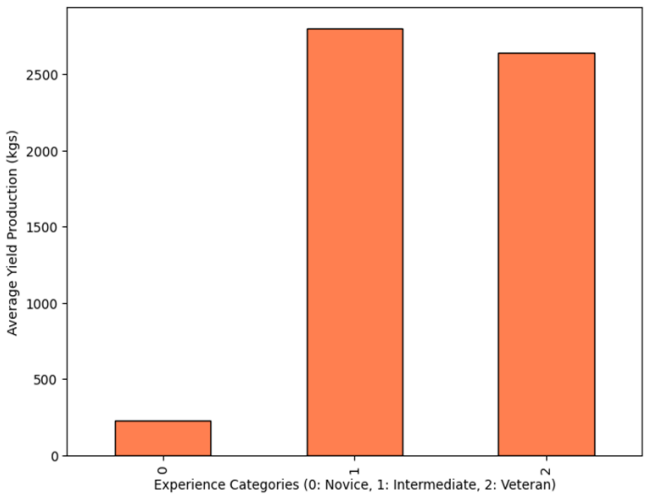

Figure 4. Average yield production vs farmers' years of experience.

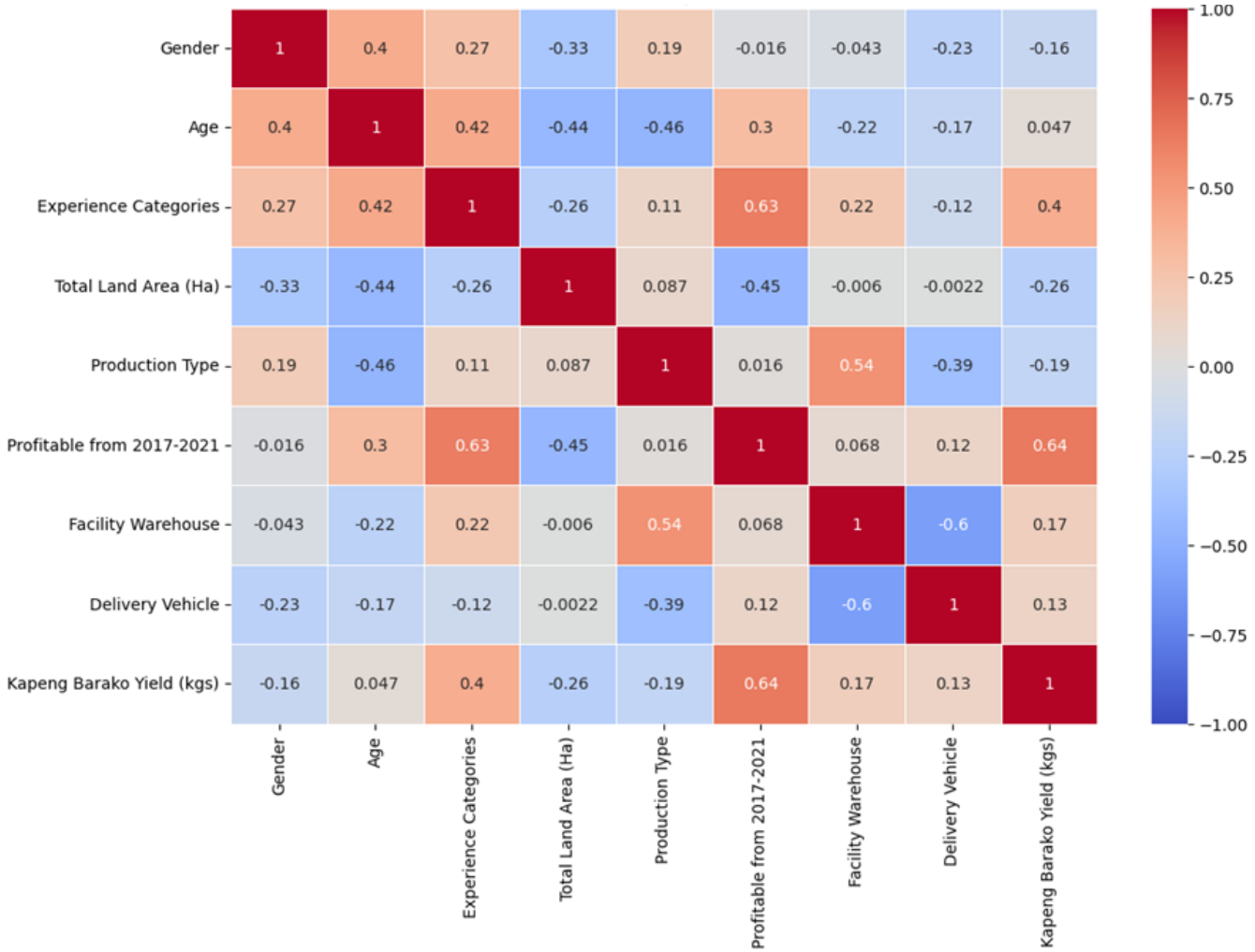

Figure 5. Correlation heatmap of farmer data of San Jose and Nasugbu, Batangas.

The correlation heatmap (Figure 5) visually maps the strength and direction of associations between various factors and *kapeng barako* production outcomes, revealing insights into the relationships affecting yield and profitability.

The analysis of various factors influencing profitability in *kapeng barako* farming from 2017 to 2021 reveals several significant correlations. The yield of *kapeng barako* exhibits a strong positive correlation with profitability (r = 0.64), indicating that farms producing higher quantities of this coffee are more likely to experience profitable outcomes. Additionally, the correlation between years of farming experience and profitability is also notable (r = 0.63), suggesting that farmers with greater experience, particularly veterans, tend to manage more profitable operations.

Furthermore, there is a moderate positive correlation (r = 0.54) between the type of production, specifically mixed-crop production, and access to facility warehouses, implying that such farms are more likely to benefit from additional storage capabilities. In contrast, the relationship between land area and profitability is moderately negative (r = -0.45), indicating that larger farms do not necessarily translate to higher profits. Similarly, a strong negative correlation (r = -0.60) exists between the availability of dedicated delivery vehicles and access to independent facility warehouses, suggesting that farmers relying on delivery vehicles may be less likely to have their storage facilities. Finally, a positive correlation (r = 0.40) between *kapeng barako* yield and farmer experience reinforces the notion that more seasoned farmers are likely to achieve higher yields in their production efforts. These findings highlight the complex interplay of experience, yield, and farm management practices in determining profitability in the *kapeng barako* industry.

The linear regression analysis of profitability relative to age, gender, and experience resulted in a mean squared error (MSE) of 0.120, reflecting the model's prediction error. The correlation coefficient (R^2) value was 0.444, indicating that 44.4% of the variance in profitability can be explained by the predictors: age, gender, and experience. The estimated regression coefficients were as follows: Gender (-0.312), Age (0.005), Experience Categories (0.393), and an intercept of -0.180. These coefficients are represented in the regression equation:

$$\text{Profitability} = -0.312 \times \text{Gender} + 0.005 \times \text{Age} + 0.393 \times \text{Experience Categories} - 0.180. \quad (1)$$

The equation reveals that Experience Categories have a positive impact on profitability, while Gender has a negative contribution, and Age shows a marginal positive influence. The coefficient for Gender (-0.312) suggests that individuals with Gender = 1 (e.g., Female) are, on average, 0.312 units less likely to be profitable compared to those with Gender = 0 (e.g., Male), after controlling for other variables. This implies a potential negative relationship between Gender and profitability. However, the absolute value of the Gender coefficient is smaller than that for Experience Categories (0.393), indicating that Experience Categories have a stronger influence on profitability than Gender. In contrast, the coefficient for Age (0.005) is much smaller, highlighting its minimal direct effect on profitability relative to Gender and Experience Categories.

4. Conclusions

This study explores the factors influencing *kapeng barako* production in San Jose and Nasugbu, Batangas, particularly focusing on the relationships between farmer demographics, farm management practices, and production outcomes. The results reveal significant correlations between variables such as farming experience, land area, infrastructure, and profitability, offering valuable insights into how these factors affect yield and economic outcomes in *kapeng barako* farming.

The findings suggest that experienced farmers are more likely to have profitable operations, indicating the importance of experience in optimizing farming practices. Interestingly, larger land areas were not associated with higher profitability, and in some cases, smaller farms with better management and infrastructure (such as access to warehouse facilities) yielded better economic results. This highlights the potential for optimizing farm size and infrastructure to improve profitability, especially for smallholder farmers. Additionally, the study points to a need for targeted support for younger and female farmers who may face barriers to accessing resources, training, and technology, thereby limiting their productivity and profitability.

From a practical standpoint, the study underscores the importance of providing better access to infrastructure, such as warehouses and delivery vehicles, which can significantly enhance the profitability of *kapeng barako* farms. Policymakers should consider initiatives that promote the efficient use of land, access to modern technologies, and capacity-building for younger and female farmers. Furthermore, integrating mixed-crop production systems with coffee farming could serve as a risk mitigation strategy, providing farmers with more stable income streams and improving overall sustainability.

For stakeholders in the agricultural sector, including government agencies and agricultural support organizations, the findings suggest that investments in infrastructure, farmer training programs, and access to financing for young and female farmers can play a crucial role in improving the economic outcomes of *kapeng barako* farming in Batangas. By addressing the specific needs of different farmer demographics and promoting sustainable farming practices, the industry can strengthen its resilience and ensure long-term success in the face of market and environmental challenges.

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