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Coffee (*Coffea* spp.) Production Systems, Postharvest Innovations, and Quantitative and Agroecological Dynamics in the Davao Region, Philippines

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Abstract

Coffee (*Coffea* spp.) is a globally significant tropical plantation crop, and the Davao Region in the Philippines is one of the country's most dynamic production zones, thanks to its favorable volcanic soils, diverse microclimates, and evolving value chain ecosystems. With an estimated 15,821.68 ha under cultivation, the region supports all major *Coffea* species. *Coffea arabica* thrives above 1,000 m asl in highland zones such as Balutakay, Maragusan, and upland Davao City; Robusta dominates lower elevations, while Liberica and Excelsa occupy smaller areas as complementary tropical crop components. Agroecological sustainability is promoted through shade-based agroforestry systems that enhance biodiversity, soil fertility, and climate resilience. Postharvest innovations such as natural, honey, and micro-lot fermentation, alongside the expansion of community-based roasting facilities, have enabled specialty-grade production and improved access to premium domestic and international markets. Emerging trends presented at the Davao Regional Coffee Expo (DRCE) 2025 include the increased adoption of climate-resilient genetic varieties, artificial intelligence-based plantation monitoring, gender-inclusive entrepreneurship, and youth participation in value-added roles such as roasting, cupping, and barista craftsmanship. However, persistent constraints, including aging plantations, low productivity, limited seedling supply, postharvest infrastructure gaps, market dependency on intermediaries, and inconsistent institutional support, continue to limit the sector's tropical crop competitiveness. This status report consolidates insights on production systems, agroecological management, postharvest innovations, and socio-economic challenges to provide a strategic outlook for strengthening coffee as a sustainable tropical plantation crop within the Davao Region and similar highland environments in Southeast Asia.

Keywords: agroecology, *Coffea* spp., postharvest processing, specialty coffee production, sustainable plantation systems, value chain development

Introduction

Coffee (*Coffea* spp.) is one of the most economically significant tropical plantation

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crops worldwide, serving as a primary livelihood source for over 25 million smallholder farming families and contributing substantially to rural development in many coffee-growing countries across Latin America, Africa, and Southeast Asia (Amrouk et al., 20205; Harvey et al., 2021; Irawan, 2025; Siles et al., 2022; Yang et al., 2022). In the global market, Arabica (*Coffea arabica* L.) and Robusta (*Coffea canephora* Pierre ex A. Froehner) dominate production and trade, with increasing demand for specialty coffee driving shifts toward quality-focused farming, postharvest innovation, and traceable value chains (Amrouk et al., 2025). In Southeast Asia, countries such as Vietnam, Indonesia, and the Philippines have experienced varied trajectories in coffee competitiveness, influenced by agroecological suitability, production systems, technological adoption, and institutional support mechanisms (Purwawangsa et al., 2024; Suryana et al., 2024; van Noordwijk et al., 2021).

The Philippines, historically recognized as one of the earliest coffee producers in Asia, has renewed national interest in revitalizing its coffee industry as part of broader agricultural diversification and high-value crop development strategies (CoffeeBI, 2024; Crawford, 1852). Among the country's key production zones, the Davao Region in Mindanao has emerged as a prominent producer of both commercial and specialty-grade coffee due to its favorable highland agroecology, volcanic soil fertility, and expanding market-oriented value chain participation (Nemenzo-Calica et al., 2025). The region cultivates the major Coffea species, including Arabica, Robusta, Liberica, and Excelsa, across differentiated elevation-based production systems, with Arabica thriving in high-altitude zones, particularly in Balutakay, Maragusan, and the upland districts of Davao City. Over the past decade, Davao has gained national and international recognition for its specialty coffee output, supported by localized innovations in postharvest processing and quality differentiation (Sumulong, 2024).

Concurrently, postharvest advancements such as natural and honey processing, micro-lot fermentation, and localized roasting facilities have allowed producers to enhance bean quality, improve value retention, and gain access to niche domestic and export markets (Aswathi & Murthy, 2024; Majeed et al., 2022; Martinez et al., 2021). These developments are further reinforced by emerging trends in climate-adaptive farming, artificial intelligence-based plantation monitoring, and diversified market positioning, which were prominently discussed during the Davao Regional Coffee Expo (DRCE) 2025. Moreover, increasing gender inclusivity within the industry has positioned women as key actors in production, processing, roasting, and enterprise management, reflecting broader social shifts within value chain governance (Nemenzo-Calica et al., 2025; Pantoja, 2025).

Despite these gains, the region's coffee sector continues to face critical constraints, including aging plantations, low production volumes, limited access to high-quality seedlings, postharvest inefficiencies, inadequate rural infrastructure, and inconsistent policy support. Smallholder farmers, especially those outside cooperatives or organized networks, continue to struggle with market access, price instability, and limited economies of scale. These constraints present challenges to sustain long-term competitiveness amid rising global quality standards and environmental uncertainties linked to climate change.

In light of these shifting paradigms, a systematic synthesis is imperative to consolidate the multifaceted interactions between contemporary production systems, postharvest technological innovations, and agroecological determinants within the Davao Region. This study provides a comprehensive diagnosis of the regional coffee sector, elucidating the complex interplay between environmental factors and market-driven transformations. By delineating current developmental trajectories, this research provides a data-driven framework to inform policy interventions and strategic research aimed at fostering resilient, inclusive, and ecologically sustainable coffee systems in tropical environments

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Materials and Methods

Study Design and Approach

This report employed a descriptive synthesis and status-oriented review approach to consolidate existing information on coffee production systems, agroecological practices, postharvest innovations, and value chain dynamics in the Davao Region, Philippines. Designed as a status-oriented documentation rather than an experimental study, it integrates statistical data, observational inputs, and stakeholder-derived insights to present a comprehensive overview of the region's coffee industry. Secondary data were examined using descriptive statistical analysis (e.g., area coverage, production volume, and yield comparisons) and qualitative thematic content analysis to identify recurring patterns, trends, and sectoral challenges across data sources. A case-based contextualization technique was used to highlight practices and trends specific to tropical highland coffee environments.

Data Sources

Information for this report was obtained from multiple secondary and experiential sources. These included regional agricultural documentation covering land use, varietal distribution, production zones, and processing practices; field-based observations from areas such as Balutakay (Bansalan), Maragusan, and upland coffee-producing districts in the Davao Region; and qualitative insights shared by farmers, processors, roasters, policymakers, women entrepreneurs, and industry facilitators during the Davao Regional Coffee Expo (DRCE) 2025. Additional perspectives were incorporated from institutional stakeholders and organizations involved in coffee value chain development and livelihood support initiatives within the region. Together, these sources provided an integrated foundation for understanding current dynamics in both production and postharvest components of the sector.

Data Analysis and Thematic Categorization

Collected information was organized into 10 thematic areas to comprehensively capture the dynamics of coffee production in the Davao Region: (1) quantitative patterns in productivity and value distribution, (2) coffee production systems, (3) varietal distribution and altitude-based suitability, (4) postharvest processing methods and quality enhancement, (5) innovative production and agroecological practices, (6) emerging industry directions from the Davao Regional Coffee Expo (DRCE) 2025, (7) markets, distribution, and value chain participation, (8) production constraints and distribution challenges, (9) agroecological conditions and climate suitability, and (10) economic importance and socio-livelihood contribution.

Mathematical and Analytical Approaches

To complement the descriptive synthesis of this study, basic mathematical and proportional analyses were applied to organize, compare, and interpret coffee production and value chain data in the Davao Region. These approaches were used to support quantitative reasoning and system-level interpretation rather than predictive modeling or experimental inference.

Descriptive mathematical measures were employed to assess productivity and land-use efficiency across provinces and production systems. Yield density (kg/ha) was calculated using reported production volumes and planted areas to enable comparison of coffee system performance across altitude-based zones and dominant varietal groupings. These indicators facilitated the evaluation of relative efficiency between highland Arabica systems and lowland Robusta-dominated areas.

Proportional and ratio-based analyses were applied to determine each province's contribution to the total regional coffee area and output. This allowed identification of spatial imbalances between land allocation and production outcomes, highlighting areas with comparatively high or low productivity relative to

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cultivated area. Such proportional assessments supported the interpretation of structural strengths and constraints within the regional coffee landscape.

Simple economic comparisons were incorporated through indicative price–yield relationships, particularly in contrasting specialty Arabica and commodity Robusta systems. Average farmgate price ranges (PHP/kg) were examined alongside yield data to infer relative value intensity per unit land area. These comparisons provided a quantitative basis for evaluating value-driven versus volume-driven production strategies.

In addition, systems-based mathematical reasoning was applied to conceptualize coffee production as an interaction of multiple variables, including altitude, varietal suitability, agroforestry structure, postharvest processing efficiency, and market access. These interacting components were interpreted using a systems approach, recognizing that changes in one component influence overall productivity, quality outcomes, and value chain performance.

These mathematical indicators were used solely for descriptive comparison and system-level interpretation, rather than predictive modelling or causal inference. The analysis supported visualization of spatial imbalances, relative efficiency across elevation zones, and contrasts between highland Arabica and lowland Robusta-dominated systems.

Ethical Considerations and Transparency

This study did not include human or animal subjects. All information were obtained from publicly available sources on non-intrusive stakeholder documentation. No personal identifiers were collected.

Scope and Limitations of The Study

The findings of this report are descriptive and based on available data and stakeholder perspectives during the reference period. While it does not include experimental validation or statistical modeling, the synthesis provides a reliable, context-specific baseline for strengthening future agronomic, socio-economic, and policy-driven studies on sustainable coffee development in tropical upland regions.

Results and Discussion

Quantitative Patterns in Productivity and Value Distribution

Application of basic mathematical indicators revealed clear spatial and structural patterns in coffee productivity across the Davao Region. Yield density analysis showed that provinces and districts with smaller cultivated areas but high-altitude Arabica production, such as Davao del Sur and the highland districts of Davao City, achieved higher average yields (353–360 kg/ha) compared with provinces characterized by larger low- to mid-elevation Robusta and Excelsa areas, such as Davao Oriental (293 kg/ha). This indicates that agroecological suitability and management intensity play a more decisive role in productivity than land area alone.

Proportional analysis further demonstrated that Davao Oriental, despite accounting for the largest share of the regional coffee area, contributes a comparatively lower share of total production due to lower average yields. In contrast, highland Arabica zones contribute disproportionately to total output relative to their planted area, underscoring the efficiency advantage of elevation-driven specialty systems. These findings align with global observations in quality-focused coffee origins where land productivity and value creation are decoupled from farm size.

Economic comparisons based on indicative farmgate prices and yield levels highlight a strong divergence between value-based and volume-based production systems. Specialty Arabica systems, despite moderate yield levels, generate substantially higher revenue per unit area due to premium prices ranging from PHP 300/kg to over PHP 500/kg. Conversely, commodity-oriented Robusta systems rely on higher volumes to remain viable but face greater exposure to price volatility and lower value retention. This contrast

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illustrates how mathematical assessment of price–yield relationships supports strategic differentiation in coffee system development.

From a systems perspective, interactions among agroecological conditions, postharvest practices, and market access explain observed patterns of productivity and income. Improvements in postharvest efficiency, micro-lot segregation, and fermentation control effectively shift system outputs upward along both quality and value dimensions, even without major increases in yield. These nonlinear gains underscore that incremental improvements in processing and quality management can yield disproportionate economic benefits.

Hence, the mathematical and analytical perspectives applied in this study reinforce the conclusion that the Davao Region's competitive advantage lies not in expanding cultivated area, but in optimizing productivity efficiency, quality differentiation, and value intensity. These quantitative insights support a development pathway centered on specialty-oriented, agroecologically adapted coffee systems rather than volume-driven expansion, consistent with sustainable tropical plantation models observed in other highland coffee regions.

Coffee Production Systems in the Davao Region

The Davao Region is a major contributor to the Philippine coffee industry, ranking second nationally in total land area devoted to coffee cultivation, with 15,821.68 ha planted as of 2024, following SOCCSKSARGEN (29,868.35 ha). Although Davao accounts for a smaller proportion of the national coffee land area than SOCCSKSARGEN, its average productivity (322 kg/ha) is comparable to, and in some cases exceeds, that of other coffee-growing regions in the country. This indicates that production efficiency in Davao is relatively high, particularly in upland systems where Arabica dominates.

Provincial-level analysis (Table 1) reveals clear spatial differentiation in production systems. Davao Oriental accounts for the largest planted area (5,687 ha) but exhibits a lower average yield (293 kg/ha), reflecting the predominance of Robusta and Excelsa in lower- to mid-elevation farms, where productivity is constrained by traditional management practices and limited postharvest infrastructure. In contrast, Davao del Sur and the highland districts of Davao City record the highest yields (353–360 kg/ha), despite

Table 1

Coffee Area, Production, and Yield in the Davao Region by Province, 2024

Province	Area planted (ha)	Production (MT)	Average yield (kg/ha)	Dominant species	Key production areas
Davao de Oro	3,480.25	1,120.80	322	Arabica, Robusta	Maragusan, New Bataan, Monkayo
Davao del Sur	2,975.43	1,050.32	353	Arabica, Robusta	Bansalan (Balutakay), Sta. Cruz, Matanao
Davao Oriental	5,687.00	1,663.00	293	Robusta, Excelsa	Lupon, San Isidro, Governor Generoso
Davao del Norte	2,360.00	785.00	333	Robusta	Talaingod, Kapalong, Asuncion
Davao City (Highlands)	1,319.00	475.00	360	Arabica	Calinan, Baguio District, Marilog, Toril
Total / average	15,821.68	5,094.12	322	—	—

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smaller cultivated areas. This yield advantage is strongly associated with high-elevation Arabica production, favorable microclimatic conditions, and greater engagement in specialty-oriented farming systems.

The clustering of production in upland zones such as Balutakay (Bansalan), Maragusan, and the Mt. Apo highlands of Calinan, Baguio, Toril, and Marilog underscores the role of altitude-driven agroecological suitability in shaping coffee system performance. These areas benefit from cooler temperatures, volcanic soils, and shade-based agroforestry, which enhance bean density and quality. Similar patterns have been reported in Arabica-growing highlands of Bengkulu (Indonesia) and Central Vietnam, where elevation and agroforestry integration significantly improve productivity and cup quality relative to lowland Robusta systems.

Compared with other Philippine regions, Davao demonstrates a more diversified production structure, cultivating all four major Coffea species. While SOCCSKSARGEN prioritizes area expansion and volume-oriented Robusta production, Davao exhibits a hybrid model that combines commercial Robusta systems with value-driven Arabica production for specialty markets. This mirrors development trajectories observed in West Java and parts of Ethiopia, where regions with smaller land areas compensate by differentiating quality, innovating in postharvest processing, and engaging directly with markets**.**

From a systems perspective, coffee production in the Davao Region remains predominantly smallholder-based, with farms typically less than 2 hectares in size. However, the increasing adoption of agroforestry, micro-lot segregation, and traceability practices suggests a gradual shift from subsistence and volume-oriented farming toward market-responsive production systems. In contrast, many lowland coffee areas in Southeast Asia remain locked in commodity-based supply chains, characterized by higher volumes but lower farmgate returns.

Hence, the data indicate that the Davao Region's comparative advantage lies not in land expansion but in agroecological suitability, elevation-driven quality potential, and integration into specialty value chains. Strengthening these advantages through plantation rejuvenation, postharvest upgrading, and cooperative-based marketing could allow Davao to follow the development path of leading specialty origins in Indonesia and East Africa, where smaller production zones achieve disproportionately high economic returns through quality-led growth.

Coffee production systems in the region are structured around smallholder farming, with many households cultivating less than 2 ha. Upland-based agroforestry is a dominant production system in which coffee is intercropped with fruit trees, forest species, or endemic shade crops. These systems support biodiversity conservation, enhance soil fertility, and reduce dependency on synthetic inputs. Production structures range from conventional Robusta-focused farms aimed at supplying local commercial demand to highly specialized Arabica systems producing for niche specialty markets. Specialty-focused producers are increasingly adopting traceability, quality grading, and micro-lot management systems to align with international buyer standards. This shift signals a gradual transition from purely volume-based production to value-driven cultivation.

Varietal Distribution and Altitude-Based Suitability

The Davao Region cultivates all four major *Coffea* species, Arabica (*Coffea arabica* L.)**,** Robusta (*Coffea canephora*)**,** Liberica (*Coffea liberica*), and Excelsa (a variant of *Coffea liberica* var*. dewevrei*), each adapted to specific altitudinal and microclimatic conditions. Altitude plays a decisive role in varietal differentiation and quality expression. Arabica, the dominant highland species, thrives above 1,000 meters above sea level (MASL), particularly in the Mt. Apo foothills, where cooler temperatures, consistent cloud cover, and volcanic soil fertility foster optimal bean development. Representative Arabica fruits from these highland farms are shown in Figure 1. Varieties such as 'Catimor' and 'Typica' exhibit fruity, floral, and complex flavor profiles that align with international specialty

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coffee standards. Premium-grade Arabica beans from Balutakay often command market prices between PHP 300/kg and PHP 500 /kg due to their superior cup quality and traceable origin. Propagation techniques such as somatic embryogenesis have been explored to improve uniformity and propagation efficiency (Ibrahim et al., 2016). Similarly, studies on hybrid vigor and genetic diversity underscore the importance of conserving varietal heterogeneity and adapting selections to site-specific microclimates (Asefa et al., 2021; Cahyono et al., 2024).

Coffea robusta, which dominates regional coffee volumes, is cultivated in lower altitudes below 800 m asl. Known for its stronger caffeine content and disease resistance, it is typically sold into commercial and instant coffee markets. *Coffea robusta* accounted for nearly 69% of regional coffee area coverage in previous years and continues to anchor mass-market supply chains. Liberica, locally recognized as Kapeng Barako, is cultivated on a limited scale in lowland areas due to its bold aromatic profile, but remains a niche product. Excelsa is grown in mid-altitude environments due to its drought tolerance and its tolerance of diverse soil acidity; it contributes to blending and diversification strategies.

This stratified varietal distribution reflects both ecological suitability and evolving market preferences. Specialty Arabica production is increasing due to shifts in global demand, whereas Robusta remains essential for domestic supply security. Varietal diversification also enhances climatic adaptability and provides farmers with multiple market entry points across commercial, specialty, and artisanal sectors.

Postharvest Processing Methods and Quality Enhancement

Postharvest processing plays a critical role in determining coffee quality, sensory attributes, and market competitiveness. In the Davao Region, three major processing techniques are practiced: natural (dry), washed (wet), and honey processing. Natural processing, widely adopted in Balutakay, involves drying whole coffee cherries under controlled conditions to enhance fermentation-based flavor expression. This method accentuates fruity, wine-like notes and is favored in specialty Arabica production. Washed processing, which involves depulping, fermentation, and rinsing, yields cleaner and brighter flavor profiles and is generally preferred for high-end export markets where clarity and consistency are valued. Honey processing is a

Figure 1

Arabica (Coffea arabica L.) Fruits Harvested from High-elevation Farms in the Mt. Apo foothills, Davao Region, Philippines

Note. The photo illustrates the characteristic red, mature cherries typical of highland Arabica, which are associated with enhanced sugar accumulation and complex flavor development under cool, volcanic agroecological conditions.

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hybrid technique that retains partial mucilage during drying, resulting in balanced sweetness and acidity.

Beyond primary processing, localized roasting and grinding facilities have become increasingly accessible through government and cooperative support. For example, Balutakay smallholders operate Department of Agriculture-supported roasting units with a 10 kg per hr capacity, allowing on-site dehulling, grinding, and packaging. Recent enterprise-based postharvest models, such as the MaCoMa Coffee Blend initiative in Davao Oriental, demonstrate how community-driven roasting and branding can enhance value retention (Leal et al., 2025). This enables farmers to capture additional value by moving beyond raw bean sales toward semi-processed or roasted products. Such facilities are critical in reducing postharvest losses, enhancing bean quality, and enabling participation in differentiated value chains.

Postharvest innovation is further tied to quality benchmarking and grading. Farmers engaged in specialty coffee production are trained in cupping standards, moisture control, and fermentation management to meet Specialty Coffee Association (SCA) criteria. This quality-centered approach has led to high Arabica scoring outcomes exceeding 85 points in international cupping events, bolstering Davao Region's identity as a specialty coffee origin.

Innovative Production and Agroecological Practices

Innovation in coffee production in the Davao Region is deeply intertwined with agroecological adaptation, specialty market expectations, and the evolving role of farmer entrepreneurship. Many highland producers have adopted micro-lot production systems, which involve segregating coffee by plot, elevation, cherry ripeness, or fermentation style. These micro-lots are processed under strict quality controls, enabling farmers to capture price premiums based on distinct flavor attributes. Such practices are particularly notable in Balutakay, where high-altitude 'Catimor' Arabica beans are processed using carefully controlled natural or honey fermentation techniques to enhance fruity complexity.

The region's volcanic terroir, especially around the Mt. Apo foothills at elevations of around 1,490 m asl, contributes significantly to differentiated cup profiles. The mineral-rich soil composition enhances nutrient uptake and bean density, leading to flavor notes that often include hibiscus, pineapple, lemon, lychee, basil, thyme, and spice, attributes that have earned recognition at international expos and cupping competitions.

Agroforestry and shade-grown systems are integral to sustainability, where coffee is integrated under diverse shade canopies, including banana, durian, lanzones, and nitrogen-fixing species. These practices mirror findings from small-scale coffee systems in Mt. Hamiguitan, Davao Oriental, where sustainability efforts are closely linked with women's participation and climate adaptation strategies (Nemenzo-Calica et al., 2025). Similar to agroforestry models in Indonesia, where *in situ* organic matter and intercropping enhance soil fertility and sustainability, Davao coffee farms integrate fruit trees and shade crops for ecosystem balance (Kusnendi et al., 2020). The integration of organic amendments, such as humic acids and biofertilizers, which are known to enhance pod and bean yields in cocoa, offers potential analogues for coffee agroforestry systems (Rohman et al., 2019).

Community-based roasting has also emerged as a localized innovation, enabling small producers and cooperatives to bypass external processors and engage in market positioning directly. Micro-roaster enterprises such as Maison Croife, Specialty Coffee Depot, Hinge, Purge, and Kaffe Arena have contributed to value localization, product differentiation, and sensory branding. Together, these innovations underscore the region's gradual transition toward a knowledge-based, quality-driven, and ecologically resilient coffee economy.

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Emerging Industry Directions from the Davao Regional Coffee Expo (DRCE) 2025

The Davao Regional Coffee Expo (DRCE) 2025 served as a vital platform for advancing innovation, sustainability, and inclusiveness within the regional coffee industry. The event emphasized climate-smart technologies, including drought-tolerant and disease-resistant varieties, AI-based monitoring tools, and adherence to Good Agricultural Practices (GAP) and the Philippine National Standard for Green Beans. It also highlighted the integration of agroforestry and cultural preservation, in which Indigenous farmers link coffee cultivation with ecological stewardship and ecotourism initiatives.

Equally significant were the themes of women's empowerment, youth engagement, and research-driven collaboration, showcasing the growing participation of women in entrepreneurship, processing, and barista professions, as well as the increasing interest of youth in coffee-related careers. Collaborative discussions among farmers, researchers, and industry stakeholders underscored the importance of capacity-building and knowledge-sharing to enhance quality, resilience, and competitiveness. Overall, DRCE 2025 illustrated a regional shift toward climate-resilient, inclusive, and innovation-led coffee development, as shown in Figure 2.

Markets, Distribution, and Value Chain Participation

The Davao Region's coffee industry participates in both domestic and international value chains, with specialty coffee serving as a gateway to premium markets. Locally, coffee is supplied to approximately 27 third-wave cafes within Davao City and to major chains in Manila. The rise of local roasters and independent cafes has helped build an internal demand ecosystem for differentiated Arabica and blended styles of Excelsa and Robusta.

Internationally, coffee from Balutakay and other Mt. Apo highland zones is exported to Japan, the United States, Canada, and Australia. Annual output in the region is estimated at approximately 10,000 metric tons, accounting for around 17.8% of national production. However, approximately 90% is consumed domestically, with only an estimated 10% entering specialty

Figure 2

Highlights from the Davao Regional Coffee Expo (DRCE) 2025

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export channels due to production limitations and consistency requirements.

Value chain participation varies based on organization and product type. Farmers linked to cooperatives or quality-driven networks are more likely to access contract-based markets, specialty premiums, and training programs. In contrast, independent smallholders often depend on intermediaries, limiting their price-negotiation power. Increasing investments in origin branding, traceability systems, and direct trade relationships may enhance market recognition and income retention.

Production Constraints and Distribution Challenges

Despite the region's upward trajectory in specialty production and international recognition, significant constraints continue to hinder its scalability and competitiveness. Insufficient production volume is a recurring issue; Davao's output contributes only an estimated 2%–5% of national demand, necessitating continued imports to meet domestic consumption. This volume limitation is exacerbated by the prevalence of aging plantations with declining productivity and inadequate renovation programs. Although the Department of Agriculture (DA) promotes rejuvenation and replanting, access to high-quality seedlings remains limited, particularly for smallholders.

Infrastructure challenges, including limited postharvest drying and milling facilities in remote upland zones, contribute to postharvest losses and inconsistent quality. Transportation constraints delay cherry delivery, affecting fermentation control and overall flavor integrity. Weak farm-to-market linkages and reliance on intermediaries further reduce marketing efficiency, particularly among growers outside established cooperatives.

Institutional support has been inconsistent, with farmers reporting delays in accessing fertilizers, financial assistance, and technical guidance. The lack of long-term, coordinated support systems undermines farmers' confidence in government-led interventions. Market price fluctuations and the absence of strong price stabilization mechanisms add uncertainty to farm-level decision-making.

From a distribution perspective, smallholders often face barriers to entering premium markets due to stringent quality requirements, certification costs, and minimum-volume thresholds set by specialty buyers. This creates a divide between organized producers with market-oriented strategies and traditional smallholders, who remain confined to local trading markets with lower, unstable profit margins. These constraints underscore the need for coordinated policy interventions, farmer-led innovations, strengthened cooperatives, improved market facilitation, and enhanced access to finance and digital tools to improve yields, efficiency, and equity in value distribution.

Agroecological Conditions and Climate Suitability

The favorable agroecological conditions of the Davao Region play a critical role in shaping its competitive advantage in specialty coffee production. Arabica thrives at elevations above 1,000 m asl, such as Mt. Apo's foothills, where cooler temperatures, consistent cloud cover, and diurnal temperature variation enhance bean density and flavor complexity. The region's upland microclimates support slow cherry maturation, improving sugar concentration and cup quality.

Soils in these regions are derived from volcanic parent materials and characterized by high organic matter content, well-drained profiles, and balanced mineral composition. These edaphic conditions facilitate root development and nutrient absorption, contributing to bean uniformity and structural integrity. Upland zones such as Calinan and the Mt. Apo highlands benefit from naturally fertile, non-acidic soils, reducing dependence on synthetic fertilizers.

Furthermore, diversified agroforestry systems contribute to microclimate regulation by moderating solar radiation, reducing water stress, and enhancing soil moisture retention. Shade-grown conditions also support insect

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biodiversity and natural pest control. These agroecological advantages underpin the region's potential to strengthen its position as a leading specialty coffee origin in the Philippines.

However, increasing vulnerability to climate variability, such as irregular rainfall, prolonged dry spells, and intensified pest outbreaks, raises concerns about future sustainability. Adaptive strategies, including the use of climate-resilient varieties, improved irrigation systems, AI-based plantation monitoring, and agroclimate forecasting, as highlighted during the DRCE 2025, are critical for maintaining productivity under evolving environmental conditions.

Economic Importance and Socio-Livelihood Contribution

Coffee is one of the top five high-value crops in the Davao Region, contributing significantly to regional agroeconomic development and rural livelihoods. Specialty Arabica, in particular, commands premium prices of PHP 300-500/kg, compared to commodity-grade Robusta, which typically sells for PHP 100–150/kg. This price differential incentivizes farmers to invest in quality improvements, fermentation control, and postharvest precision.

Coffee farming has considerable socio-economic importance in upland communities, including Indigenous Peoples (IPs) and marginalized smallholders. In many areas, particularly among Bagobo Tagabawa communities, coffee cultivation is interwoven with cultural identity, land preservation, and communal cooperation. Enhanced participation in specialty markets has helped strengthen local entrepreneurship, cooperative formation, and community resilience.

Gender participation is increasingly evident, as women engage not only as farm laborers but also as key actors in processing, roasting, sensory evaluation, marketing, and café ownership. Similar observations were reported in Mt. Hamiguitan coffee communities, where women's involvement in farm management and decision-making is pivotal to sustainable production and climate resilience (Nemenzo-Calica et al., 2024). The DRCE 2025 showcased female-led enterprises such as Bean O'Clock, Kohi Mame, and Brew Friends, highlighting coffee as a platform for women's economic empowerment.

Government and NGO investments have further strengthened rural economic activity. Initiatives include the DA's PHP 10 million investment in cooperative-based processing centers (e.g., BACOFA Cooperative) and PHP 8 million in community roasting hubs in Davao de Oro. These investments enable farmers to retain greater value through localized postharvest processing and direct-to-market strategies.

Beyond farm-level income, coffee supports downstream employment in logistics, roasting, retail, barista services, tourism, and mixology-based beverage innovation. Specialty coffee competitions and youth-focused training initiatives, such as barista and latte art battles during the DRCE 2025, further frame coffee as a viable pathway for youth employment and entrepreneurship.

Collectively, these outcomes confirm that coffee production in the Davao Region is not merely an agricultural endeavor but a key driver of agro-industrial development, social equity, and cultural revitalization. Aligning future growth with sustainability, inclusivity, and innovation will be central to harnessing the full developmental potential of coffee in tropical plantation landscapes.

Conclusions

This study synthesizes the coffee production landscape of the Davao Region, Philippines, highlighting its distinct comparative advantage rooted in highland agroecology, volcanic soils, and shade-based agroforestry. The region utilizes spatially stratified systems, with Arabica dominating high-elevation specialty zones while Robusta, Excelsa, and Liberica sustain diversified production at lower altitudes. Adoption of specialty postharvest innovations, including natural, honey, and washed processing, alongside micro-lot fermentation, has successfully transitioned the sector from

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volume-based production toward value-driven, high-scoring tropical systems. Despite these advancements, persistent structural challenges remain, such as aging plantations, low production volumes, and infrastructure gaps. Insights from the 2025 Davao Regional Coffee Expo suggest a development trajectory centered on genetic improvement, digital monitoring, and inclusive entrepreneurship for women and youth. Ultimately, Davao serves as a scalable model for tropical plantation landscapes, where long-term sustainability depends on climate-resilient agroecology, plantation rejuvenation, and stronger research–industry collaboration to ensure equitable economic returns.

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