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Preferences of Coffee Farmers for Attributes of Selected Coffee Technologies in the Philippines

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ABSTRACT

This paper looked into the preferences of 151 coffee farmers for the attributes of selected coffee technologies. The study was done to help guide technology developers in crafting postharvest processing facilities for coffee which their target market will need which can lead to a higher probability of commercialization of new coffee technologies. The study examined the preferences for attributes for coffee dryers, moisture meters, coffee depulpers, and coffee sorters using the Analytic Hierarchy Process (AHP) framework. The results revealed that the quality of the final product is the top priority for coffee farmers when choosing a coffee dryer. Non-destructiveness is the most important attribute of coffee moisture meters. The adaptability of the machine to different varieties is the primary concern for coffee depulper. Finally, accuracy is the most important factor when selecting a coffee sorter. Technology innovators should consider the abovementioned attributes in developing coffee technologies to improve their marketability.

Keywords: *preferences, attributes, coffee technologies, analytical hierarchy process*

Introduction

Crops, livestock, poultry, forestry, and fisheries compose the agriculture sector of the Philippines. Each subsector contributes and plays an important role in the lives of every Filipino. During the third quarter of 2022, the value of production at constant 2018 prices decreased by 1.0 percent. The livestock and poultry subsectors showed a positive growth rate with 2.50 percent and 1.80 percent, respectively. However, a 6.60 percent decrease in production from the fisheries subsector and 1.0 percent in crops were observed (PSA 2022).

Traditional agricultural methods are no longer enough to sustain the agriculture industry, which faces numerous challenges. In this regard, innovation is essential. Agricultural innovations play a crucial role in achieving sustainable intensification of systems, which could result in higher levels of productivity, efficiency in resource utilization, profitability, resilience, and/or improved food and nutritional security (Castillo-Valero and Garcia-Cortijo 2021). Nations such as Thailand, India, and Japan invest in technology development as one of their significant drivers for growth. V. Raghupathi and W. Raghupathi (2019) cited that as nations develop, investment in

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research and development (R&D) should increase to encourage technical innovations and new products. In the Philippines, one of the ways the government addresses social, environmental, and economic issues is by investing in new technologies. Datta, Reed, and Jessup (2013) conducted a study that revealed that only one out of 3,000 innovation ideas is successfully transformed into a commercial product. This situation also applies in the Philippines, where numerous fully-developed technologies remain uncommercialized. In the 2022 Global Innovation Index (GII), the Philippines' ranking dropped by eight places from the previous year to 59th place. The country's position in innovation inputs also decreased from 72nd in 2021 to 76th in 2022. Furthermore, innovation outputs declined from 40th in 2021 to 51st in 2022, primarily due to lower scores in knowledge and technology outputs, which depend on knowledge creation, impact, and diffusion. he critical challenges that the sector faces include inadequate human resources in science-technology-innovation (STI) and R&D, underdeveloped research culture and productivity, insufficient R&D spending, underdeveloped linkages among R&D, technology, and innovation stakeholders, lack of focus on information about markets or users and market system requirements, the need for a more robust intellectual property (IP) culture, and barriers to building an innovative and entrepreneurial culture (NEDA 2022).

On the other hand, technology developers often neglect the economic aspect of innovation. The market for the product is often not identified, and the cost-competitiveness is normally given less importance. Some technology developers fail to develop products based on the demands of the actual users of the technology. In the study of Bellon (2001), farmers cannot be considered a uniform group, as their preferences and priorities differ significantly. As a result, there are numerous factors that may affect farmers' choices of technologies. The factors influencing their choices may include the end product's characteristics, socio-economic factors, personal opinions and attitudes, perceived risks, the social and cultural context, and the extent of their information resources (Hellyer, Fraser and Haddock-Fraser 2012). Thus, the most effective approach to promoting the use of new technologies is to create suitable technologies that account for the diversity of farmers, their limitations in production, and the key factors that truly impact their ultimate choices in agricultural pursuits. Incorporating farmers' preferences for attributes of technologies is necessary for advancing technological innovations.

The Philippines stands out as one of the nations that cultivate four coffee types: Arabica, Excelsa, Liberica, and Robusta (Peace and Equity Foundation 2016). Nonetheless, the Philippine Statistics Authority reports that there has been an overall decrease in production of about 16.17%, which means that production has gone down from 72,341.82 tons in 2015 to 60,640.95 tons in 2020. Over the last four years (2016-2019), the area dedicated to coffee cultivation has experienced a slight annual decrease of around 1.8%, but in 2020 it saw an increase. Moreover, over the last decade, there has been a decline in yield per hectare by approximately 2.53% annually, and at the same time, the yield per bearing tree has also decreased by about 2.09% per year.The coffee industry faces significant challenges, including poor postharvest practices and outdated postharvest facilities (Department of Agriculture 2022).

The use of unsuitable pulping and hulling practices, as well as extended and delayed drying periods, contributes to the subpar quality of coffee beans. As a result, broken and black beans are formed, and moisture content increases, leading to a decrease in quality. This issue has been consistently observed in the coffee industry, as noted by Idago and Dela Cruz in 2015, as well as the Philippine Coffee Industry Roadmap from 2021-2025. Moreover, coffee farmers get lower prices for their green coffee beans if sold not sorted or not sorted properly. The same study revealed that the lack of technologies like depulpers, dryers, moisture meters, and coffee sorters are the major causes of inefficiencies in the postharvest system. Therefore, these four coffee technologies will be assessed in this study.

Given the situations above, this study will look into the preferences of coffee farmers for the attributes of selected coffee technologies. This is expected to help guide technology developers in crafting postharvest processing facilities for coffee which their target market will need. The results of the study can lead to a higher probability of commercialization of new coffee technologies. Similarly, this study can be a reference for potential investors in preparing sound business plans.

Methodology

Selection of Study Area

The study was conducted in the top coffee-producing regions in the country. The covered areas were Region 11 (Davao City, Davao del Sur, Compostella Valley), Region 12 (Sarangani, Sultan Kudarat, North Cotabato), and ARMM (Sulu). The volume of production served as the basis for selecting these sampled regions.

Sampling Procedure

Stratified random sampling was used to select respondents from the combined latest lists of coffee farmers provided by the top-producing coffee regions. The sample size was determined using Cochran's formula. There were a total of 2,173 recorded coffee farmers. The sample size calculated considering a 90% level of confidence and a 10% level of significance was 153 respondents. However, only 151 respondents were interviewed due to the location of farmers. The area is characterized by rugged terrain, which made it impossible for the researchers to interview two of the farmers.

Types and Sources of Data

The study used primary and secondary data. Primary data were gathered in 2018 through surveys with the aid of a pre-tested questionnaire. Furthermore, key informant interviews and literature reviews gathered information about the technologies and attributes to which these technologies were evaluated.

Analytical Procedures

Descriptive analysis was used to describe coffee farmers' socio-economic characteristics, farm profile, and postharvest practices. To evaluate coffee technologies, several technology attributes were used.

For the coffee dryer, the four general attributes identified were; 1) speed of process, 2) aesthetics and ergonomic design, 3) cost of technical and labor requirements and 4) quality of the final product. Speed of process refers to the volume and rate of coffee dried. Aesthetics and ergonomic design refer to the technology's appearance, dimension, durability, and ease of use. The cost of technical and labor requirements refers to the expenses involved in using the technology, including labor requirements, energy efficiency, and technical know-how. The quality of the final product refers to the quality of the coffee after drying.

For the coffee moisture meter, the four general attributes identified were; 1) accuracy, 2) speed of process, 3) aesthetics and ergonomic design, and 4) non-destructive. Accuracy refers to the trueness of the moisture content determined. The speed of process refers to the rate at which the result is obtained. Aesthetics and ergonomic design refer to the technology's appearance, dimension, and ease of use. Non-Destructive refers to the ability of the technology to determine moisture content without damaging the parchment coffee or green coffee beans.

For the coffee depulper, the four general attributes identified were; 1) efficiency, 2) aesthetics and ergonomic design, 3) adaptability, and 4) speed of process. Efficiency refers to the percentage of pulp-parchment separation. Aesthetics and ergonomic design refer to the durability, appearance, and ease of use of the technology. Adaptability refers to the ability of the technology to depulp multiple coffee varieties. Speed of process refers to the rate at which coffee berries are depulped.

For the coffee sorter, the four general attributes identified were; 1) accuracy, 2) speed of process, 3) adaptability, and 4) cost of technical and labor requirements. Accuracy refers to the capability of discreetly measuring coffee berries' size and color quality differences and separating them according to the desired quality. Speed of process refers to the rate at which coffee berries are sorted by size and color quality differences. Adaptability refers to the ability of the technology to sort multiple coffee varieties. The cost of technical and labor requirements refers to the expenses involved in using the technology, including labor requirements and technical know-how.

However, the study was unable to include the price of the technology as an attribute. The article is based on a research project investigating technology prices and the willingness to pay. As such, the price of the technology was not included as one of the attributes due to the existence of a Confidentiality and Non-Disclosure Agreement with the respondents. Thus, this is the limitation of the study.

The respondents' preferences for these attributes were elicited by requesting them to compare these attributes against each other in terms of which one is more important for them. The comparison follows the Analytic Hierarchy Process (AHP) framework/scale. Table 1 shows the AHP scale used supposing two items (it can be attributes or technologies), i and j, are being compared.

Table 1. The AHP Scale

Rating	Interpretation
9	Attribute/Technology i is extremely preferred over Attribute/Technology j
7	Attribute/Technology i is very strongly preferred over Attribute/Technology j
5	Attribute/Technology i is strongly preferred over Attribute/Technology j
3	Attribute/Technology i is moderately preferred over Attribute/Technology j
1	Attribute/Technology i is equally preferred over Attribute/Technology j
1/3	Attribute/Technology j is moderately preferred over Attribute/Technology i
1/5	Attribute/Technology j is strongly preferred over Attribute/Technology i
1/7	Attribute/Technology j is very strongly preferred over Attribute/Technology i
1/9	Attribute/Technology j is extremely preferred over Attribute/Technology i

Values in Between for compromises

The evaluation part of the technology started with the elicitation of preferences for the four technology attributes. Each respondent was asked to perform pairwise comparison between two attributes at a time using the AHP scale, as explained earlier. Responses from the AHP method were processed through the linear programming model presented below. Such responses were inputted into the linear programming model (executed through MATLAB) to come up with the respective weights of the technology attributes. Each weight is interpreted as the extent the attribute is preferred so that the higher the weight of an attribute, the higher it is preferred or prioritized over other attributes.

Decision variables:

n_{ij}	be negative deviation associated to minimum consistency goal	$i, j \in \{1, 2, 3, \dots n\};\ i < j$	(1)
p_{ij}	be positive deviation associated to minimum consistency goal	$i, j \in \{1, 2, 3, \dots n\};\ i < j$	(2)
v_i $/v_j$	be the variable associated to the weight of attribute i/j	$i, j \in \{1, 2, 3, \dots n\}$	(3)

Objective:

$$\sum_{i=1}^{n-1} \sum_{j=i+1;j\neq i}^{n} (n_{ij} + p_{ij}) \tag{4}$$

Constraints:

$$-v_i + v_j - n_{ij} + p_{ij} = -l_{ij} \qquad \forall(i < j) \tag{5}$$

$$\sum_{i}^{n} v_i = 0 \tag{6}$$

$$n_{ij}, p_{ij} \geq 0 \qquad \forall(i < j) \tag{7}$$

Where:

$$l_{ij} = log\ log\ a_{ij} \qquad \forall(i < j); a_{ij} \neq 0 \tag{8}$$

$$n_{ij} = \frac{1}{2}\left[\left|l_{ij} - v_i + v_j\right| + \left(l_{ij} - v_i + v_j\right)\right] \qquad \forall(i < j) \tag{9}$$

$$p_{ij} = \frac{1}{2}\left[\left|l_{ij} - v_i + v_j\right| - \left(l_{ij} - v_i + v_j\right)\right] \qquad \forall(i < j) \tag{10}$$

Finally, the final weights obtained are as follows:

$$w_i = \frac{e^{v_i}}{\sum_{i=1}^{n} e^{v_i}} \tag{11}$$

The linear programming model used is a simplified version of that of Dopazo and Ruiz-Tagle (2011). The model shown also is aimed at minimizing the inconsistencies of the responses of the respondents in relation to their preferences on the different technology attributes. Such inconsistencies naturally arise from having more than two items being evaluated.

The results are based on individual responses. To get the overall weight for each attribute, W_i, the individual weights obtained were simply averaged (arithmetic mean). These values represent now the overall preference for each attribute. If w_{ik} is the weight of attribute i from respondent j, then W_i is expressed as:

$$W_i = Average\ (w_{ik}) \tag{12}$$

Results and Discussion

Socio-Demographic Profile off Coffee Farmers

The study gathered information on various demographic factors of coffee farmers. These respondents are described to be the decision-makers with regard to the use of the technology. The age range of the respondents was from 20 to 89 years old, with an average age of 51, and the majority were above 60. This suggests that coffee farming is mainly done by an aging population, indicating a potential lack of young farmers entering the profession. Most coffee farmers interviewed were male, comprising 79% of the respondents. This could be due to coffee production's strenuous physical demands and coffee farms' remote location in mountainous regions.

Regarding civil status, 84% of the respondents were married, while only a few were single, separated, or widowed. In terms of income, the average monthly income of the coffee farmers ranged from PHP1,500.00 to PHP300,000.00, with an average of PHP62,825.16. This suggests that most coffee farmers earn a decent income and are considered middle-class. The years of formal schooling for coffee farmers ranged from 1 to 14 years, with an average of 9 years. This indicates that most of them did not have a college education. Lastly, 67% of the coffee farmers interviewed were members of an organization, with most being part of a farmers' association in their area. Table 2 shows the socio-economic profile of coffee farmers.

Table 2. Socio-economic Profile of Coffee Farmers (n=151)

Variable/ Parameter		Frequency
Age		
	25 or less	5 (3%)
	26-35	16 (11%)
	36-45	30 (20%)
	46-55	38 (25%)
	56-60	19 (13%)
	Above 60	43 (28%)
	Min	20
	Max	89
	Average	51
	Median	51
Sex		
	Male	120 (79%)
	Female	31 (21%)
Civil Status		
	Single	12 (8%)
	Married	127 (84%)
	Widow	9 (6%)
	Separated	3 (2%)
Monthly Income		
	Min	1,500.00
	Max	300,000.00
	Average	62,825.16
	Median	40,000.00
Years of Formal Schooling		
	6 or less	57 (39%)
	10-Jul	55 (36%)
	15-Nov	36 (25%)
	Min	1
	Max	14
	Average	9
	Median	10
Membership to Organization		
	With	102 (67%)
	Without	49 (33%)

Farm Profile of the Large Coffee Farmers.

Table 3 presents the farm profile of the coffee farmers. This table describes the characteristics of the farm concerning its operation and other pertinent farm information. In a farm set-up, the decision to purchase specific inputs or equipment lies with the owner. Almost all (98%) coffee farmers interviewed are farm owners. The average year in farming is 28 years, with most respondents having farmed for 11 to 20 years. On the other hand, the average years specific in coffee farming was 22 years. The average total farm area for coffee farmers is 5.6 hectares, with most having less than 5 hectares of land. The average farm area devoted to coffee production is 2.5 hectares, but most farmers have 1 hectare or less for coffee production. Many farmers have shifted to other crops like coconut and cacao, decreasing the area devoted to coffee production. During harvesting, farms with a size of 1 hectare or less have an average yield of 524.00 kilograms of green coffee beans. As the farm size increases, there is a corresponding increase in average yield, indicating the potential benefits of scale and improved efficiency.

Table 3. Farm profile of Coffee Farmers (n=151)

Variable/ Parameter		Frequency
Position/Role in the Farm		
	Tenant	2 (1%)
	Leasehold	1 (1%)
	Owner	148 (98%)
Years in Farming		
	10 or less	20 (13%)
	11-20	39 (26%)
	21-30	35 (23%)
	31-40	30 (20%)
	41-50	18 (12%)
	Above 50	9 (6%)
	Min	2
	Max	62
	Average	28 (Php 62,825.16)
	Median	28 (Php 40,000.00)
Years in Coffee Farming		
	10 or less	43 (28%)
	11-20	37 (25%)
	21-30	29 (19%)
	31-40	26 (17%)
	41-50	13 (9%)
	Above 50	3 (2%)
	Min	1
	Max	62
	Average	22
	Median	20
Total Farm Area (hectares)		
	5 or less	103 (68%)
	6-10	34 (23%)
	11-15	6 (4%)
	16 - 20	2 (1%)
	21 -25	3 (2%)
	Above 25	3 (2%)
	Min	1
	Max	60
	Average	5.6
	Median	3.5
Average Yield per Farm Size Range (green coffee beans in kilogram)		
	1 or less	524.00
	1.1- 5	5,613.08
	5.1-10	8,750.34

Description of Postharvest Practices

This section will focus mainly on drying, depulping, moisture determination, and coffee sorting since the technologies assessed were for the following postharvest practices. Dehulling will be discussed in the section on depulping since most coffee farmers practice the dry method of processing.

Drying

As can be seen in Table 4, the majority of the coffee farmers, or 144 of them, practice drying. The remaining seven farmers were selling their coffee as fresh cherries. Most of them dry berries, meaning that most (97%) of the coffee farmers apply the "dry method," which dries the whole coffee berry. The common practice of drying is sun drying on the roads, pavements, or tarpaulins. On average, farmers have been sun drying their coffee for 23 years. The average frequency of drying is about four times, with a maximum of 15 times per season. This means that farmers do not dry all their harvest in one drying. The average duration of drying experienced by coffee farmers is seven days or one week before they can dehull their dried coffee berries.

Table 4. Description of the Drying Practices of Coffee Farmers (n=151)

Variable/Parameter		Frequency
Practice Drying of Coffee Berries		
	Yes	144 (95%)
	No, Sold as fresh berries	7 (5%)
Forms of Coffee Dried		
	Berries	97 (67%)
	Parchment Coffee	47 (33%)
Coffee Drying Practice		
	Sun drying	122 (85%)
	Improvised All-Weather Solar Dyer	3 (2%)
	Elevated Solar Dryer	19 (13%)
Years in Current Practice		
	Min	2
	Max	68
	Average	23
	Median	20
Material Used in Drying		
	Net	8 (6%)
	Tarpaulin	53 (37%)
	Road/Pavement	72 (50%)
	Sawali (bamboo)	11 (8%)
Frequency of Drying		
	Min	1
	Max	15
	Average	4
	Median	3
	Mode	4
Duration of Drying (in days)		
	Min	1
	Max	30
	Average	7
	Median	6
	Mode	7

Moisture Content Determination

Among the 151 farmers interviewed, only ten were using a moisture meter to test the moisture content of their coffee, whether it is dried coffee berries, parchment coffee, or green coffee beans. Table 5 shows that most coffee farmers determine the moisture content of the parchment by peeling the sample dried berry and biting it to determine its brittleness. If the parchment coffee is already hard, then it is already dried. On the other hand, 35 farmers only touch or feel the coffee berries to know if it is dried or not. They just rely on their years of experience to determine the right feel of the beans. Thirty-three of the 151 farmers determines the coffee berries' dryness by shaking the dried berry. If the coffee berries rattle inside the dried pulp, it is already dried. Other farmers determine dryness through the berries' shiny appearance and weight reduction. The average year in practicing their current moisture determination method is 19 years. This means that they have been doing their current method for a long time, and coffee farmers might already be skilled.

Table 5. Description of the Moisture Determination Practices of Coffee Farmers (n=151)

Variable/Parameter	Frequency
Practice of Moisture Determination	
feel/touch method	35 (24%)
weight method	6 (4%)
biting/brittleness of parchment	52 (36%)
shiny appearance	8 (6%)
shaking	33 (23%)
use of moisture meter	10 (7%)
Years in Current Practice	
Min	2
Max	56
Average	19
Median	16

Depulping

As can be seen in Table 6, only 47 coffee farmers are practicing depulping. They commonly use a mechanical/manual wooden/steel depulper or mechanical coffee depulper that are electric and sometimes diesel operated. The minimum years in practicing depulping is 13, while the maximum is 47. On average, the coffee farmers depulped twice every season. Lack of storage facilities causes the low number of coffee farmers practicing depulping. Depulped coffee berries are more prone to molds when not properly stored than dried ones. Also, according to the farmers, depulping will only incur an additional cost since it will still be dehulled after drying.

Table 6. Description of the Depulping Practices of Coffee Farmers (*n=151*)

Variable/Parameter	Frequency
Practice Depulping	
Yes	47 (31%)
No, Sold as fresh berries	7 (5%)
No, Practice Dehulling	97 (64%)
Coffee Depulping Practice	
Manual Wooden Depulper	6
Manual Steel Coffee Depulper	12
Mechanical Coffee Depulper	29
Frequency of Depulping	
Min	1
Max	5
Average	2
Median	20

Table 6. Continued…

Variable/Parameter		Frequency
Years in Current Practice		
	Min	13
	Max	47
	Average	19
	Mode	18

Table 7 shows that 64% of the farmers practice dehulling. This means that they dried the fresh coffee berries first and then dehulled it to get the green coffee beans. Coffee dehulling is usually done through a service provider or a corn mill. Sixty-four percent of the farmers, or 76 of them, pay at least Php2.00 up to Php5.00 per kilogram of dried and dehulled coffee berries. Other methods include using coffee dehuller and manual dehulling by hand or pounding. The average years of coffee farmers practicing dehulling are 24 years, with maximum years in the practice of 68 years. Coffee farmers usually dehull their dried coffee berries five times every season. Some farmers store their dried coffee berries and then dehull them when prices increase.

Table 7. Description of the Dehulling Practices of Coffee Farmers (n=151)

Variable/Parameter		Frequency
Practice Dehulling		
	Yes	97 (64%)
	No, Sold as fresh berries	7 (5%)
	No, Practice Depulping	47 (31%)
Coffee Dehulling Practice		
	Pounding	14 (14%)
	Manual dehulling (by hand)	1 (1%)
	Corn Mill	62 (64%)
	Dehuller	20 (21%)
Frequency of Dehulling		
	Min	1
	Max	8
	Average	5
	Median	4
	Mode	5
Years in Practicing Dehulling		
	Min	2
	Max	68
	Average	24
	Median	20

Coffee Sorting

As shown in Table 8, only 57 or 38% of the coffee farmers who were interviewed sorted their green coffee beans before selling it. As mentioned previously, sorting can increase the price of green coffee beans. However, most farmers do not practice sorting and just sell their green coffee beans all in. All of the 57 farmers sort manually using a sorting table. The average times of sorting in a season are thrice, while the average duration of sorting is six days. The coffee farmers have practiced sorting for an average of 14 years. Some farmers hired laborers to sort at Php2.00 to Php5.00 per kilogram.

Table 8. Description of the Sorting Practices of Coffee Farmers (n=151)

Variable/Parameter		Frequency
Practice Sorting		
	Yes	57 (38%)
	No, Sold as fresh berries	7 (5%)
	No, Sold GCB all-in	87 (58%)
Coffee Sorting Practice		
	Sorting Table	57 (100%)
Frequency of Sorting		
	Min	1
	Max	7
	Average	3
	Median	3
	Min	1
Duration of Sorting		
	3-5 days	37 (65%)
	6-8 days	13 (23%)
	more than 8 days	7 (12%)
	Min	3
	Max	10
	Average	6
	Median	5
Years in Current Practice		
	Min	1
	Max	51
	Average	14
	Median	7

Farmer's preference for technology attributes

In this study, four general technology attributes were identified for each coffee technology. Each attribute was explained to the respondents before the preferences for the four technology attributes were elicited.

<u>Coffee Dryer</u>

The speed of the drying process, the aesthetic and ergonomic design, the cost of technical and labor requirements, and the quality of the final product are the main considerations of coffee farmers in choosing a coffee dryer. Most respondents prefer a slow drying process to ensure the quality of green coffee beans. They also prefer a dryer with a high loading capacity since they practice the "dry method" and require a large area to dry their fresh coffee berries.

In terms of aesthetic and ergonomic design, farmers want an all-weather coffee dryer that can be easily assembled and transferred since their coffee farms are located on the mountainsides. The dryer should be light, durable, and not a permanent structure. This is because sudden outpour of rain is a major problem in drying coffee on roads or pavements.

The cost of technical and labor requirements is another factor that farmers consider. The traditional method of drying coffee requires high labor, and many farmers do not pay for labor costs. Thus, they prefer a less labor-intensive dryer that can be easily operated.

Lastly, farmers want a coffee dryer that produces good quality green coffee beans. The quality of the beans is crucial since it affects the price. Therefore, they prioritize the quality of the final product when choosing a coffee dryer.

Table 9. Quantitative Assessment on the Technology Attributes of Coffee Dryer

Attribute	Average	Overall Rank	Rank Frequency			
			1	2	3	4
Speed of process	25.92%	2	35	64	30	22
Aesthetics and ergonomic design	17.89%	4	11	17	59	64
Cost of technical and labor requirements	19.61%	3	18	21	56	56
Quality of the final product	36.58%	1	97	45	3	6

As seen in Table 9, the quality of the final product has the highest weighted average. This implies that this is the attribute of the solar dryer that is most important to the respondents. Coffee farmers want a solar dryer to give them good quality dried coffee beans. This was followed by the speed of process. As mentioned above, coffee farmers do not want fast drying. However, because of the changing weather, drying is prolonged, which takes twice or thrice as long as the farmers' favorable drying duration. Cost of technical and labor requirements ranked third, while aesthetics and ergonomic design had the lowest weighted average; hence, it is not a very important attribute for the respondents.

Coffee Moisture Meter

The farmers surveyed had several requirements for selecting a moisture meter for their coffee. Accuracy was a top priority, as many moisture meters on the market are not calibrated for coffee, leading to inaccurate readings. Respondents wanted a moisture meter precisely calibrated for coffee to ensure precise measurements. Additionally, the speed of process was important to the farmers, as traditional methods of determining moisture content do not even take a minute. Respondents sought a fast and accurate method of determining moisture content.

Respondents also considered aesthetics and ergonomic design when choosing a moisture meter. Since coffee farms are often located in remote areas, the farmers preferred a portable and handy moisture meter that they could easily take to different locations. Moreover, the non-destructive nature of the moisture meter was also a key factor. Many available moisture meters still require grinding or cracking of the coffee beans before testing, affecting the sample's value. Therefore, the farmers preferred a non-destructive moisture meter that would allow them to sell their coffee samples even after moisture determination.

Table 10. Quantitative Assessment on the Technology Attribute of Coffee Moisture Meter

Attribute	Average	Overall Rank	Rank Frequency			
			1	2	3	4
Accuracy	27.65%	2	45	53	34	19
Speed of process	22.01%	3	15	34	66	36
Aesthetics and ergonomic design	18.65%	4	21	22	27	81
Non-destructive	31.68%	1	79	39	21	12

As can be seen in Table 10, the non-destructive attribute has the highest weighted average. This implies that this is the attribute of the moisture meter that is most important to the respondents. Aesthetics and ergonomic design had the lowest weighted average; hence, it is not a very important attribute for the respondents.

Coffee Depulper

The coffee farmers prioritize efficiency, aesthetics and ergonomic design, adaptability, and speed of process when it comes to coffee depulper. Although most of them do not practice coffee depulping, they still aim for a high pulp-parchment separation efficiency. They prefer a coffee depulper that is light and durable and both electricity and fuel operated. Since some of the respondents plant multiple varieties of coffee, they want a depulper that can depulp all coffee varieties. In addition, they want a depulper that can depulp a high volume of coffee berries in a short period, as manual depulping takes time.

Table 11. Quantitative Assessment on the Technology Attributes of Coffee Depulper

Attribute	Average	Overall Rank	Rank Frequency			
			1	2	3	4
Efficiency	28.68%	2	57	38	41	15
Aesthetics and ergonomic	16.37%	4	13	15	33	90
Adaptability	29.59%	1	61	43	29	18
Speed of process	25.36%	3	41	48	41	21

As seen in Table 11, adaptability has the highest weighted average. This implies that this is the attribute of the coffee depulper that is most important to them. However, its difference with efficiency is slight, which means that efficiency is also an important attribute that respondents put importance on. Aesthetics and ergonomic design have the lowest weighted average; hence, it is not very important attribute for the respondents.

Coffee Sorter

In the coffee industry, sorting green coffee beans is a crucial step affecting the final product's quality and price. Traditionally, manual sorting using sorting tables has been a common practice. While the respondents acknowledged that laborers are already experts in this activity and can produce somewhat accurate results, the process is time consuming and can lead to inconsistencies in sorting. As a result, they desired a more accurate sorting process that could adhere to prevailing standards. Additionally, respondents wanted a fast-sorting machine with high capacity to increase efficiency. Furthermore, adaptability was also a key factor, as different coffee varieties can vary in appearance. Finally, the cost of technical and labor requirements was a concern, and the respondents preferred a machine that could be operated by only a few laborers to sort large volumes of green coffee beans.

Table 12. Quantitative Assessment on the Technology Attributes of Coffee Sorter

Attribute	Average	Overall Rank	Rank Frequency			
			1	2	3	4
Accuracy	26.96%	1	55	38	26	32
Speed of process	23.65%	3	38	34	48	31
Adaptability	26.72%	2	55	35	39	22
Cost of technical and labor requirement	22.67%	4	30	36	28	57

As seen in Table 12, accuracy has the highest weighted average. This implies that this is the attribute of the coffee sorter that is most important to them. Respondents wanted accuracy because any impurities can affect the price of green coffee beans. The cost of technical and labor requirements had the lowest weighted average; hence, it is not a very important attribute for the respondents. Respondents stated that even if sorting is costly, its value addition is much higher. Since respondents are used to slow manual sorting, it is acceptable if the machine is not that fast. Therefore, the speed of process is third in the overall ranking. Also, it is worth noting that the differences in the weighted average for accuracy and adaptability were very slim. This also implies that these attributes are equally important to the respondents. Adaptability is also important for the farmers since most of them have more than one variety of coffee being planted.

Priorities for the Coffee Technologies

Respondents were also asked about their priority among the four technologies. Results showed that the respondents, given a limited budget, will prioritize coffee dryer. According to them, drying was the bottleneck in postharvest practices; therefore, it was their priority among the four technologies. The respondents ranked the coffee sorter second. Respondents were excited about the coffee sorter since it will make their sorting more efficient and accurate. In addition, traders provide free moisture determination to the farmers. Coffee depulper ranked third because of the prevailing practice of the respondents, which was the dry process method which does not require a depulper. The coffee moisture meter was rated last because, according to them, they can already accurately determine the moisture content of their coffee with their traditional practice.

Table 13. Priorities for the Coffee Technologies

Technology	Overall Rank	Average Weight
Coffee Dryer	1	29.70%
Coffee Moisture Meter	4	16.98%
Coffee Depulper	3	25.08%
Coffee Sorter	2	28.24%

Summary, Conclusion and Recommendations

The Philippines is unique among coffee-producing countries because it cultivates all four varieties of coffee - Arabica, Excelsa, Liberica, and Robusta (A Primer on PEF's Priority Commodities: Industry Study on Coffee, n.d.). However, in recent years, there has been a decrease in coffee berry production in the country due to a decline in both the area dedicated to coffee cultivation and the number of productive coffee trees over the past decade. Additionally, many coffee trees in the country are already old and unproductive, exacerbating the decline in coffee supply. These trends are attributed to farmers shifting to other crops, land conversion to non-agricultural uses such as real estate and recreation, and urbanization. As a result of low coffee berry production and suboptimal postharvest practices, the quantity and quality of coffee beans have declined. Due to insufficient domestic output to meet demand, the Philippines imports coffee.

Outdated postharvest facilities and poor postharvest practices cause poor-quality coffee beans. These practices include inadequate depulping and dehulling methods, prolonged periods of drying that result in broken and black beans, and poor-quality beans due to high moisture content (Idago and Dela Cruz 2015). Sorting is also an issue as many farmers find it laborious and sell their produce at a lower price. Even with sorting, there are still impurities present due to the limitations of manual sorting. The study of Idago and Dela Cruz (2015) also revealed that the lack of technologies, such as depulpers, dryers, moisture meters, and coffee sorters, are major contributors to inefficiencies in the postharvest system.

The study examined the preferences for attributes for coffee dryers, moisture meters, coffee depulper, and coffee sorters using the Analytic Hierarchy Process (AHP) framework. Primary data were gathered from 151 coffee farmers. The results revealed that the quality of the final product is the top priority for coffee farmers when choosing a coffee dryer. Non-destructiveness is the most important attribute of coffee moisture meters. The adaptability of the machine to different varieties is the primary concern for coffee depulper. Finally, accuracy is the most important factor when selecting a coffee sorter. Among all four coffee technologies, the coffee dryer is the priority of coffee farmers.

Technology innovators should consider the abovementioned attributes in developing coffee technologies to increase the marketability of the technology that they will make. Moreover, given a limited capital, they should prioritize fabricating coffee dryers, among other technologies, since it is also the priority of the coffee farmers.

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