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Marketing Strategies and Production Profitability of Charcoal in the Rural Zone of Lubumbashi, Democratic Republic of the Congo

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Abstract: The low efficiency of carbonization techniques reduces the income of charcoal producers and exacerbates deforestation in the Miombo woodlands. This study examines marketing strategies and the profitability of charcoal production in the rural area of Lubumbashi. Activity monitoring, from production to sale, was conducted with 20 professional charcoal producers from the villages of Maksem, Sela, Luisha, and Mwawa. Economic and statistical analyses show that charcoal is mainly sold in the village (55%), in Lubumbashi (35%), and in the forest (10%). Overall, the activity is profitable: sales generate an average profit of CDF 462,218.78 (approximately USD 225.47), with a profit margin of 0.46 and a benefit–cost ratio of 0.86. The 57 kg packaging format is the most profitable, with an average profit of CDF 661,062.18 (USD 322.47), a profit margin of 0.66, and a benefit–cost ratio of 1.96. In contrast, the 29 kg bag results in losses: –CDF 24,009.60 (–USD 11.71), a profit margin of −0.20, and a benefit–cost ratio of −0.19. These findings indicate that profitability is influenced by the point of sale, packaging type, and season. Sales price, along with production and marketing costs, are the main economic determinants. Despite apparent profitability, the sustainability of this activity remains a concern. This study recommends improving production practices, structuring of charcoal producers through legally recognized associations, standardizing packaging, and implementing per-kilogram pricing in order to enhance profitability while reducing the pressure on forest resources.

Keywords: natural resources; deforestation; charcoal; profit; profitability; DR Congo

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Academic Editors: Alin Emanuel Artene and Aura Emanuela Domil

Received: 31 March 2025
Revised: 21 April 2025
Accepted: 24 April 2025
Published: 26 April 2025

Citation: Mukendi, N.K.; Muteya, H.K.; Okothomas, B.E.; Nghonda, D.-d.N.; Kalumbu, J.T.; Ndjibu, L.N.; Berti, F.; Sikuzani, Y.U.; Mwine Fyama, J.N.; Lebailly, P.; et al. Marketing Strategies and Production Profitability of Charcoal in the Rural Zone of Lubumbashi, Democratic Republic of the Congo. *Sustainability* **2025**, *17*, 3915. https://doi.org/10.3390/su17093915

1. Introduction

Forests are home to essential biodiversity that ensures the proper functioning of ecosystems [1]. They play a crucial role for both humanity and the ecological balance by serving as reservoirs of carbon and biodiversity, while also providing vital resources, particularly fuelwood, which remains indispensable for many populations [2,3]. In addition to fuelwood, these ecosystems provide non-timber forest products such as caterpillars, fruits, and mushrooms, which contribute to food security and household income [4]. Among these resources, charcoal is a widely used fuel in sub-Saharan Africa, where it represents the primary source of domestic energy [5,6]. Approximately 195 million people rely on it as their main energy source, and another 200 million use it as a secondary source [7].

In most cities of the Democratic Republic of the Congo (DR Congo), charcoal remains the primary source of wood-based energy. Its use is particularly widespread in Kisangani [8], with especially high usage rates in other urban centers: 98% in Kinshasa and Lubumbashi [9,10], 99% in Goma, and 97% in Bukavu [11,12]. However, charcoal production is characterized by low yields, mainly due to the continued reliance on traditional earth kilns [13]. These kilns have carbonization yields of 10% in Lubumbashi [14,15], 12.8% in the Yangambi Biosphere Reserve, and 28.1% on the Batéké Plateau [16]. Some improved techniques, such as those implemented by agroforestry producers in Mampu, can achieve carbonization efficiencies of approximately 20% [17]. Such a low carbonization efficiency significantly contributes to deforestation, even though the DR Congo is home to nearly 60% of the Congo Basin's forests [2,18]. The country's heavy dependence on charcoal thus constitutes a major obstacle to sustainable forest management. This issue is further aggravated by the lack of viable alternative energy sources, the practice of slash-and-burn agriculture, and the environmental impacts of small-scale logging operations [19,20].

Deforestation particularly affects the Miombo forest in the Lubumbashi region, due to human activities such as charcoal production [21–23]. Urban supply is becoming increasingly difficult as forest cover declines. For example, the charcoal supply area for Lubumbashi lost more than half of its forested land between 1990 (77.90%) and 2022 (39.92%), with forests gradually being replaced by wooded savannas, grasslands, or agricultural land [23]. As a result, charcoal extraction is progressively shifting farther away from urban centers, leading to increased transport volumes and longer travel distances—an indicator of the extent of deforestation caused by this activity [22].

Despite its negative environmental impacts, the charcoal sector remains an important economic driver, generating income at various levels of the value chain [16,24]. In Lubumbashi, the sector represents an estimated added value of USD 50 million per year, with 59% coming from production; wholesale and retail sales represent 17% and 16%, respectively [10]. For charcoal producers, this activity can cover up to 80% of household expenses [25]. However, several constraints hinder the profitability of production, including heavy taxation, poor transportation infrastructure [14,26,27], and high labor costs, which directly affect producers' incomes [28,29].

Numerous studies have been conducted in Lubumbashi and its rural area on the charcoal supply chain. Most of them describe the actors involved—producers, transporters, vendors, and consumers—using value chain, supply chain, or socio-economic approaches [14,26,30]. While some of these studies mention the profitability of charcoal production, they do not examine its underlying determinants, nor do they explore the relationship between profitability and the sustainability of the activity in the region.

To address this gap, the present study aims to shed light on local economic dynamics and to inform public policies that promote the sustainable management of this essential resource for both urban and rural households in Lubumbashi.

In efforts to improve charcoal producers' incomes, a better understanding of the interactions between economic parameters is essential for effective sector management. It is therefore crucial to analyze the factors that influence profitability, such as selling price, transportation costs, taxes, and labor compensation, in order to propose appropriate policies. This study is based on the hypothesis of economic rationality, which posits that producers make decisions aimed at maximizing profit based on available resources and the technical laws of production [31].

In this context, the present research was initiated to analyze marketing strategies and the financial profitability of charcoal production in the rural areas surrounding Lubumbashi. It was guided by the following two research questions: Do the marketing practices implemented by professional charcoal producers influence the financial profitability of this activity? What economic parameters determine profitability at the point of sale? This study was based on the following hypotheses: Marketing practices, such as the diversification of packaging types, sales locations, and the season of sale, influence the financial profitability of charcoal production in rural Lubumbashi. Selling price and production costs determine this profitability. Households in Lubumbashi prefer larger packaging formats, which increases their profitability [27,32]. Selling price, as well as production and marketing costs, increase with distance from the production site [33–35]. Finally, the increase in selling price during the rainy season has a positive effect on profitability during that period [36,37].

2. Materials and Methods

2.1. Study Area

This study was conducted in the rural area surrounding Lubumbashi, located in the southeastern part of the Democratic Republic of Congo. This area serves as the main charcoal supply basin for the city of Lubumbashi, extending up to 150 km around the urban center [30]. It is characterized by a Cwa-type climate, according to the Köppen classification system [38]. Two distinct seasons are observed: a dry season and a rainy season, the latter lasting from November to March, with an average annual rainfall of approximately 1232 mm. The mean annual temperature is 20 °C, with variations ranging from a minimum of 8 °C to a maximum of 32 °C [39].

The dominant vegetation in the region consists of Miombo woodlands [40]. The soils are mainly lateritic, composed of red, red ochre, and yellow earths [39]. This forest ecosystem represents a vital resource for local communities, providing both timber and non-timber forest products essential to their livelihoods [25]. The main rural economic activities include agriculture, charcoal production, fishing, fruit gathering, and the collection of mushrooms and caterpillars [39]. Charcoal production is a particularly important economic activity in this region, involving a wide range of actors from various backgrounds [30,41].

The rural area of Lubumbashi includes numerous charcoal-producing villages, among which the study sites were selected. These villages are located within an 80 km radius of the city: Luisha (on the Likasi road), Maksem (on the Kasenga axis), Sela (on the Kinsevere route), and Mwawa (on the Kasumbalesa axis). Luisha, approximately 86 km from Lubumbashi, is the most distant village from the urban center (Figure 1). In addition to forest exploitation, Luisha is also known for artisanal mining activities. Mwawa is located 57 km from the city, while Sela, at about 45 km, is the closest. These two villages are primarily characterized by agricultural activities and charcoal production. Maksem, situated 60 km from Lubumbashi, is known for its agricultural operations, particularly the presence of numerous farms, whose activities exert significant pressure on forest resources, leading to notable degradation.

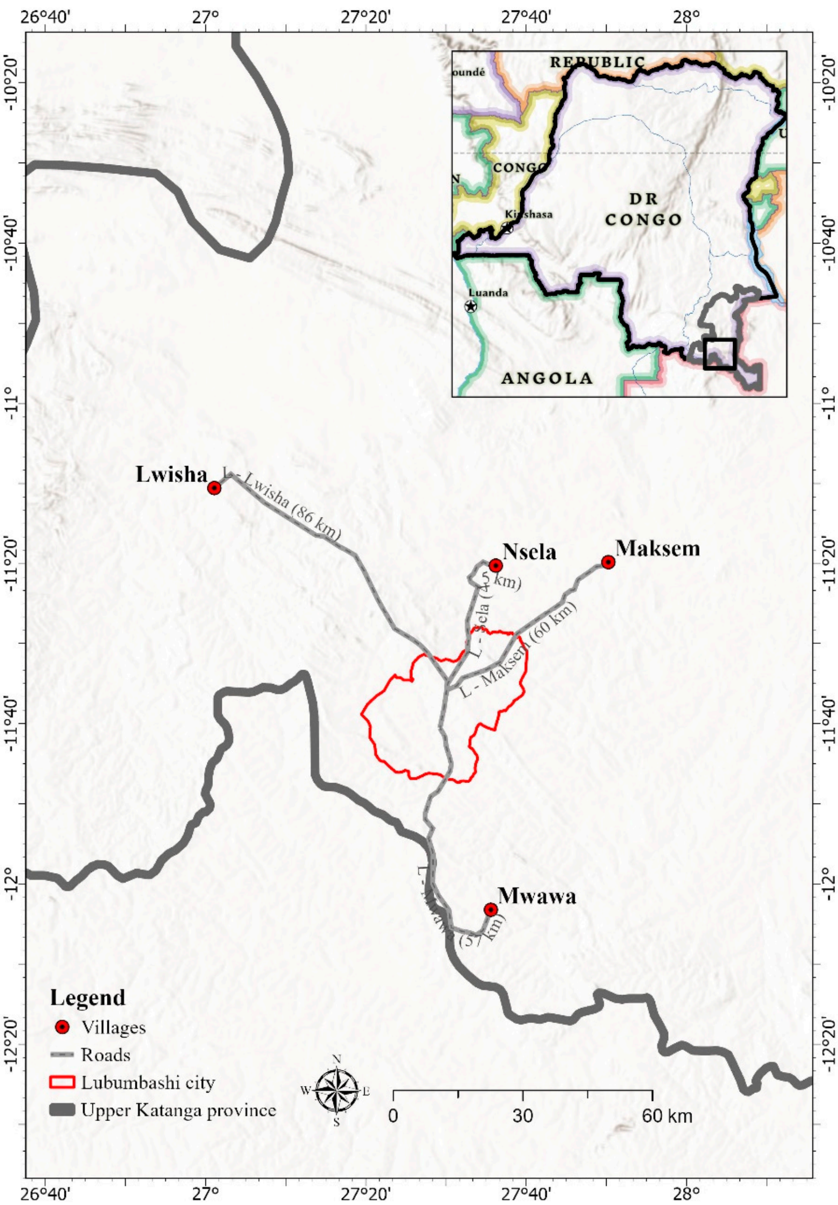

Figure 1. Geographic location of the selected villages in the rural zone of Lubumbashi, showing their respective distances from the urban center. Map generated using ArcGIS by Héritier Khoji.

2.2. Methodology

2.2.1. Selection of Villages

To select the four villages included in this study, a preliminary survey was conducted among charcoal sellers at 14 wholesale storage and sales sites located within the city of Lubumbashi. The objective of these surveys was to identify the main origins of the charcoal marketed and consumed in the city. Based on this information, exploratory field visits were carried out in 16 villages identified as the primary suppliers, according to the responses collected from warehouse vendors. This exploratory phase took place between 7 July and 7 August 2020.

The four villages ultimately selected stood out due to the high intensity of forest exploitation for charcoal production. This intensity was particularly evident in the large number of stored charcoal bags and the frequent presence of resellers coming from Lubumbashi. In addition, these villages were easily accessible and connected to neighboring charcoal-producing villages, facilitating a network effect and mutual reinforcement among them.

Finally, the selected villages were among the most populated in their respective areas, as indicated by the number of households recorded in each (Table 1).

Table 1. Characteristics of charcoal-producing villages studied in the rural area of Lubumbashi (DR Congo). Data were collected during the exploratory phase, specifically between 7 July and 7 August 2020.

No.	Village	Geographical Coordinates	Number of Households
1	Maksem	11°19′ S; 27°50′ E	2133
2	Sela	11°20′ S; 27°36′ E	1150
3	Mwawa	12°03′ S; 27°35′ E	163
4	Luisha	11°10′ S; 27°01′ E	2670
		Total	6116

Source: 2020 annual reports from local administrative offices, BUCODED (2020), and [42].

2.2.2. Sampling

The sampling process was carried out in several stages (Figure 2), the first of which involved identifying charcoal producers among household heads in the four selected villages. To determine the sample size, we used the Bernoulli formula [41,43,44], as presented below (Equation (1)). This method led to the selection of a total of 258 household heads, distributed across the four study villages.

$$n = \frac{1.64^2 \times N}{1.64^2 + I^2 \times N - 1} \tag{1}$$

where N = total population size, corresponding to the total number of households in the selected villages; n = sample size; I = acceptable margin of error (set at 10%); and 1.64 = critical value for a 90% confidence level.

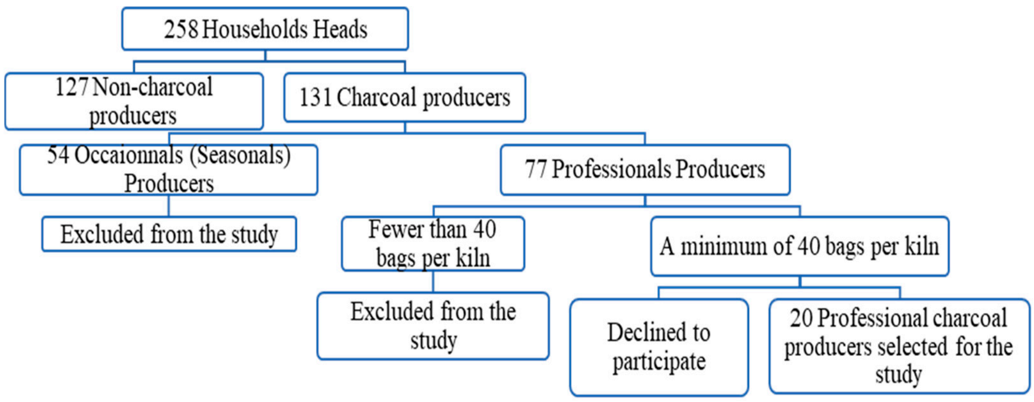

Figure 2. Selection process of the 20 professional charcoal producers monitored in this study between 4 January and 28 September 2022, from the villages of Mwawa, Sela, Maksem, and Luisha.

Among the 258 household heads surveyed, 131 were involved in charcoal production. Of these, only 20 professional producers were selected for this study, based on several rigorous selection criteria. One of the main criteria was that charcoal production constituted their primary—if not exclusive—economic activity, carried out consistently throughout the year. In other words, these producers engaged in charcoal production regardless of the season, whether during the dry or rainy period [14,26,30]. In addition, these producers were distinguished by above-average production volumes. The minimum output required per kiln was set at 40 bags [26]. This selection also reflects the fact that, for these producers, charcoal represents a significantly more important source of income compared to others.

These criteria also made it possible to monitor activity consistently across both seasons, which was essential for collecting the economic data required for this study.

The distribution of the monitored producers by village was as follows: 6 in Luisha, 5 in Maksem, 5 in Sela, and 4 in Mwawa. This distribution takes into account the variation in the number of households from one village to another, which influences the size of the charcoal-producing population. Accordingly, more producers were selected in Luisha, while fewer were selected in Mwawa, in order to ensure appropriate representativeness for each village context.

2.2.3. Data Collection

Data collection for this study was carried out between 4 January and 28 September 2022. It involved tracking charcoal producers throughout the entire production and marketing process [15,16].

Data were collected using a survey questionnaire or monitoring form, allowing for the recording of various economic variables. These included the selling price, various production costs (labor, packaging), and marketing-related expenses (transportation, taxes, handling, and storage fees). Additional information was gathered regarding marketing strategies, such as the place and season of sale, as well as the types of packaging used. The number of bags sold was also recorded.

Data collection was carried out based on the availability of the producers, who informed us in advance of the date and time at which they could be observed. Regarding packaging, four distinct types of bags were identified, each differing in volume and weight (Figure 3). The largest, locally referred to as “3 pas”, had an average weight of 57 kg. The second, called “2 pas”, weighed approximately 43 kg. The third, known as “1 pas”, had an average weight of 36 kg. The final type, known as “kipupu”, was the smallest, with an average weight of 29 kg. Based on the arithmetic mean of these four packaging types, the average weight of a sack of charcoal was estimated at 41.3 kg [14,30].

Figure 3. Illustration of the types of charcoal packaging identified in the rural area of Lubumbashi. (**A**) Largest bag, weighing approximately 57 kg, characterized by a wide upper section. The visible sticks at the end of the bag correspond to a length equivalent to three handspans (a local unit of measurement used by charcoal producers). (**B**) Bag weighing 43 kg, with a moderately wide upper section; the sticks at the end measure about two handspans. (**C**) Bag weighing 36 kg, narrower in shape, with sticks measuring about one handspan. (**D**) Bag weighing 29 kg, the smallest, with no visible extension; the end typically measures less than one handspan. Photos taken during the surveys conducted between 4 January and 28 September 2022.

2.2.4. Data Analysis

The data collected in the field through the monitoring of charcoal producers enabled the necessary statistical analyses for this study. This was made possible by the analysis of data using SPSS software (version 21). Descriptive statistics were used to calculate means and standard deviations for quantitative variables such as selling price, production costs, and marketing costs. They were also used to compute proportions. Statistical inference, including analysis of variance (ANOVA) and Student's *t*-test, was conducted to compare the means of quantitative variables. ANOVA was used to test for the existence of significant differences, particularly with regard to selling prices and costs depending on the place of sale (production site, village, and the city of Lubumbashi). Student's *t*-test was applied to compare selling prices across seasons. When the *p*-value was below 0.05, differences were considered statistically significant. Multivariate analysis was also conducted, particularly through the study of correlations. A correlation matrix was developed to assess the influence of various economic variables on profit. The coefficient of determination (R^2) was used to measure the strength of the relationship between profit and, on the one hand, selling price and, on the other, total costs (production and marketing). Strong relationships were identified when the R^2 value was close to 1, indicating a strong dependence between the variables. Likewise, negative values were interpreted as indicating an inverse relationship [45,46].

Profitability was assessed through a financial analysis based on economic calculations aimed at determining three key indicators: profit, profit margin, and the benefit–cost ratio. Profit analysis made it possible to evaluate the economic performance and managerial capacity of professional charcoal producers in the rural area of Lubumbashi. A negative profit indicates a loss, meaning that the resources mobilized for production did not generate sufficient returns to cover the costs incurred [47,48]. Profit and the profit margin were calculated using the method proposed by [49]. It is worth noting that the calculation of profit is based first on the determination of revenue, as presented in the following formula:

$$\mathrm{GR} = BS \times \mathrm{ASP} \tag{2}$$

where GR = gross revenue; BS = number of bags sold; ASP= average selling price.

$$\mathrm{PP} = (\mathrm{BS} \times \mathrm{ASP}) - (\mathrm{TC} + \mathrm{TXC} + \mathrm{LC} + \mathrm{MC} + \mathrm{AC}) \tag{3}$$

where PP = profit per producer; TC = transport cost; TXC = tax cost; LC = labor cost; MC = material cost; AC = access cost.

Costs related to materials and land access were not included in this study. According to [14], access to resources in this area is open, unregulated, and generally considered free of charge, which significantly reduces production costs.

Calculations were based on a kiln-level analysis, with monitoring of charcoal producers beginning at the tree-felling phase. Therefore, the land acquisition stage was not included. Moreover, the duration and conditions of access to forest resources vary widely among individuals and across time periods, making it difficult to incorporate this factor into the economic analysis. In this context, the formula proposed by [49] was adapted as follows:

$$PP = (BS \times \mathrm{ASP}) - (\mathrm{TC} + \mathrm{TXC} + \mathrm{LC}) \tag{4}$$

Profit margin was computed using the following formula:

$$PM = \frac{NP}{GR} \tag{5}$$

where PM = profit margin; NP = net profit; GR = gross revenue.

Gross revenue corresponds to the income generated from the sale of charcoal [50]. Profit was calculated to determine the amount actually retained by charcoal producers after the sale. It represents the difference between gross revenue and the total costs associated with the production and marketing process [10].

The profit margin is a complementary indicator to revenue and profit. It assesses the level of profitability by expressing the share of profit in the producer's total revenue [26,49]. Finally, the benefit–cost ratio was calculated to evaluate the economic and financial viability of charcoal production activities conducted by professional producers in the rural area of Lubumbashi. This ratio takes into account the total production and marketing costs, as well as the profit generated [51], with B = benefit; C: cost.

When the B/C ratio is greater than 1, the activity is considered financially profitable. This means that for every 1 CDF invested in charcoal production, more than 1 CDF is generated in return.

When the B/C ratio is less than 1, the activity is not financially profitable.

3. Results

3.1. Charcoal Sales Locations

The results show that 55% of charcoal producers sell their product within their production village, while 35% transport it to Lubumbashi for sale. In contrast, only 10% of sellers market their charcoal directly at the carbonization site. These findings highlight that the majority of producers prefer to sell locally within their own village (Figure 4).

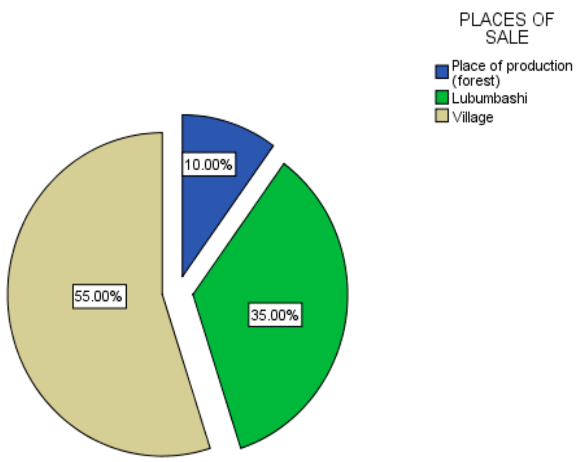

Figure 4. Distribution of charcoal sales by point of sale. "Point of sale" refers to three locations: the forest, the village, and the city of Lubumbashi. "Village" includes the four study sites: Mwawa, Sela, Luisha, and Maksem.

3.2. Charcoal Selling Prices in the Lubumbashi Region

The results indicate that a 57 kg bag is sold at an average price of CDF 16,104.17 ± 5913.64, while the smallest 29 kg bag is sold at CDF 6250.00 ± 1541.10. Moreover, the selling price fluctuates depending on the season. During the dry season, prices range from CDF 5000.00 ± 2121.32 to CDF 15,291.67 ± 3963.64, whereas in the rainy season, they range from CDF 6625.00 ± 1376.89 to CDF 16,916.67 ± 7722.80. However, no statistically significant differences were found between the two seasons for each packaging type ($p > 0.05$, Student's *t*-test).

It is also worth noting that, depending on the type of packaging, the selling price of charcoal increases with distance from the production site. A 57 kg bag is sold at an average of CDF 10,000.00 ± 0.00 in the forest, CDF 13,406.25 ± 1731.73 in the village, and CDF 25,333.33 ± 2516.61 in Lubumbashi. Similarly, the 29 kg bag is sold at CDF 4500.00 ± 707.11 in the village and CDF 7125.00 ± 853.91 in Lubumbashi (Table 2). These findings indicate that charcoal selling prices vary according to packaging type and point of sale and also tend to increase during the rainy season.

Table 2. Variation in charcoal selling prices (mean ± standard deviation) by season, sales location, and packaging type in Lubumbashi and its rural area. The exchange rate used is 2050 CDF per 1 USD, based on the September 2022 rate (Source: BCDC). n = number of observations. * Statistically significant differences were considered at $p < 0.05$.

Variables	Packaging Types				
	57 kg Bag	**43 kg Bag**	**36 kg Bag**	**29 kg Bag**	**All Bag Types**
Season					
Rainy season (n = 11)	16,916.67 ± 7722.80	11,666.67 ± 2886.75	8000.00 ± 3464.10	6625.00 ± 1376.89	12,045.46 ± 5090.43
Dry season (n = 9)	15,291.67 ± 3963.64	11,000.00 ± 5354.13	10,166.67 ± 2362.90	5500.00 ± 2121.32	12,435.19 ± 4364.42
p-value (Student's *t*-test)	0.656	0.855	0.421	0.461	0.863
Sales Location					
Production site (n = 2)	10,000.00 ± 0.00	-	6000.00 ± 0.00	-	7000.00 ± 1414.21
Lubumbashi (n = 7)	25,333.33 ± 2516.61	15,333.33 ± 1527.53	11,666.67 ± 577.35	7125.00 ± 853.91	15,250.00 ± 6860.21
Village (n = 11)	13,406.25 ± 1731.73	8250.00 ± 2061.55	7500.00 ± 0.00	4500.00 ± 707.11	11,242.43 ± 3135.91
Total	16,104.17 ± 5913.64	11,285.71 ± 4151.88	9083.33 ± 2905.45	6250.00 ± 1541.10	12,220.84 ± 5191.03
p-value (ANOVA)	0.000 *	0.004 *	0.002 *	0.021 *	0.084

3.3. Costs Incurred in Charcoal Production in the Lubumbashi Region

3.3.1. Costs at Different Stages of Production and Marketing

The processes of charcoal production and marketing in the Lubumbashi region involve various costs. To produce a single bag of charcoal, producers spend an average of CDF 770.61 on labor related to tree felling and wood cutting. During kiln construction—specifically for wood stacking and covering—expenses amount to CDF 1165.00. In addition, forest taxes are estimated at CDF 275.00.

The total production cost when the bag is sold directly in the forest is CDF 2987.60. This cost increases by CDF 2000.00 when the sale takes place in the village. When charcoal is marketed in Lubumbashi, additional costs must be considered, including transportation (CDF 3000.00), handling (CDF 1000.00), storage fees (CDF 428.47), and urban taxes (CDF 400.00). These results show that the total costs of charcoal production and marketing are made up of several expenses incurred by producers, and these costs vary depending on the sales location (Table 3).

Table 3. Distribution of production and marketing costs (mean ± standard deviation) per bag of charcoal produced, according to sales location in Lubumbashi and its surrounding rural area. The exchange rate used is 2050 CDF per 1 USD, based on the rate in September 2022 (source: BCDC).

Activities	Sales Location			
	Forest	**Village**	**Lubumbashi**	**All Sales Locations**
Tree felling and wood cutting	770.61 ± 0.00	0	0	0
Stacking and covering	1165.00 ± 0.00	0	0	0
Packaging	777.00 ± 0.00	0	0	0
Transport to village	0	2000.00 ± 447.21	0	0
Transport to Lubumbashi	0	0	3000.0 ± 577.35	3000.00 ± 577.35
Forest taxes	275.00 ± 35.35	285.00 ± 85.51	300.00 ± 95.74	289.47 ± 82.63
Village taxes	0	261.11 ± 48.59	221.43 ± 26.73	243.75 ± 44.25
Lubumbashi taxes	0	0	400.00 ± 76.38	400.00 ± 76.38
Storage fees	0	0	428.57 ± 48.79	425.00 ± 46.29
Loading and unloading	0	0	1000.00 ± 0.00	1000.00 ± 0.00

3.3.2. Costs by Packaging Type, Sales Location, and Season

For all packaging types combined, total costs range from CDF 308,236.80 ± 184,771.51 in the village to CDF 816,703.20 ± 605,344.36 in Lubumbashi. However, when analyzed by packaging type, costs do not show significant variations across seasons. In contrast, when packaging type is not considered, significant seasonal differences are observed in relation to sales location during the rainy season ($p < 0.05$, ANOVA).

For the 57 kg bag, costs in Lubumbashi during the rainy season amounted to CDF 618,622.20 ± 304,084.10, compared to CDF 182,844.00 ± 0.00 during the dry season. For the 43 kg bag, costs remained high during both periods: in Lubumbashi, they were estimated at CDF 813,655.80 ± 0.00 in the rainy season and CDF 351,974.70 ± 213,328.88 in the dry season. These results indicate that the production and marketing costs of charcoal vary depending on the sales location and increase with distance from the production site (Table 4).

Table 4. Production and marketing costs (mean and standard deviation) by sales location, season, and packaging type. Values are presented in Congolese Francs (CDF). The exchange rate used is 2050 CDF per 1 USD, based on the September 2022 rate (Source: BCDC). n = number of observations. * $p < 0.05$ indicates statistically significant differences.

Variables (Rainy Season)	Sales Location			
	Forest	Village	Lubumbashi	*p*-Value (ANOVA)
57 kg bag (n = 7)	108,426.50 ± 0.00	296,324.27 ± 44,746.39	618,622.20 ± 304,084.10	0.177
43 kg bag (n = 3)	-	44,672.00 ± 12,635.15	813,655.80 ± 0.00	0.013 *
36 kg bag (n = 3)	215,304.05 ± 286,961.54	-	502,821.00 ± 0.00	0.563
29 kg bag (n = 4)	35,737.60 ± 0.00	-	73,137.60 ± 0.00	-
All packaging types (n = 11)	269,517.30 ± 210,292.43	202,810.88 ± 145,838.85	847,939.05 ± 83.247,58	0.000 *
Variables (Dry season)				
57 kg bag (n = 6)	-	268,032.00 ± 191,204.51	182,844.00 ± 0.00	0.705
43 kg bag (n = 4)	-	156,352.00 ± 157,939.37	351,974.70 ± 213,328.88	0.407
36 kg bag (n = 3)	-	178,688.00 ± 0.00	461,681.10 ± 575,341.53	0.757
29 kg bag (n = 2)	-	17,868.80 ± 0.00	639,954.00 ± 0.00	-
All packaging types (n = 9)	-	308,236.80 ± 184,771.51	816,703.20 ± 605,344.36	0.085

3.4. Charcoal Profitability in the Lubumbashi Region

Our results show that charcoal sales in Lubumbashi and its surrounding rural areas are profitable, with an average profit of CDF 462,218.78 ± 368,408.12, a corresponding profit margin of 0.46, and a benefit–cost ratio of 0.86. When considering packaging types, the 57 kg bag demonstrates a strong economic performance, with an average profit of CDF 661,062.18 ± 490,466.79, a profit margin of 0.66, and a benefit–cost ratio of 1.96. In contrast, the smallest 29 kg bag yielded negative profitability, with an average loss of CDF −24,009.60 ± 63,197.62, a profit margin of −0.20, and a benefit–cost ratio of −0.19. These results indicate that marketing the 57 kg bag is the most profitable option, whereas selling the 29 kg sack results in a financial loss, taking into account all production and marketing costs (Table 5).

Table 5. Profitability of charcoal by packaging type (mean ± standard deviation). GR: gross revenue; TC: total costs, PM: profit margin, and B/C: benefit–cost ratio. Values are presented in Congolese Francs (CDF). The exchange rate used is 2050 CDF per 1 USD, based on the September 2022 rate (source: BCDC).

Variables	Packaging Types				
	57 kg Bag	43 kg Bag	36 kg Bag	29 kg Bag	All Packaging Types
GR	1002,895.83 ± 732,423.68	444,142.86 ± 463,584.02	500,000.00 ± 444,124.31	119,666.67 ± 182,228.06	860,441.79 ± 583,612.39
TC	336,636.15 ± 237,673.40	274,236.17 ± 290,650.58	339,246.55 ± 324,531.78	123,160.51 ± 229,546.67	462,218.78 ± 368,408.12
Profit	661,062.18 ± 490,466.79	169,906.69 ± 176,284.76	160,753.45 ± 149,554.33	−24,009.60 ± 63,197.62	398,223.01 ± 405,813.80
PM	0.66	0.38	0.32	−0.20	0.46
B/C	1.96	0.62	0.47	−0.19	0.86

3.5. Determinants of Charcoal Profitability in the Rural Area of Lubumbashi

3.5.1. According to Sales Location

The results indicate that total costs are negatively correlated with profit when sales occur at the charcoal production site ($R^2 = -1.00$, or −100%). No correlation was found between profit and total costs in the village or in Lubumbashi. Our findings also show that the selling price is positively correlated with profit, whether at the production site, in the village, or in Lubumbashi. These results confirm that at the production site, an increase in production costs leads to a decrease in profit, and vice versa. Conversely, profit increases in direct relation to the selling price of charcoal, regardless of the sales location (Table 6).

Table 6. Correlation between profit and various economic profitability parameters, by charcoal sales location. TCF = total costs at the production site (forest); TCV = total costs in the village; TCL = total costs in Lubumbashi; SPF = selling price at the production site (forest); SPV = selling price in the village; SPL = selling price in Lubumbashi.

Variables	Profit	TCF	TCV	TCL	SPF	SPV	SPL
Profit	1	−1.000 **	−0.105	−0.463	1.000 **	1.000 **	1.000 **
TCF	−1.000 **	1	b	b	−1.000 **	b	b
TCV	−0.105	b	1	b	b	0.039	b
TCL	−0.463	b	b	1	b	b	−0.463
SPF	1.000 **	−1.000 **	b	b	1	b	b
SPV	1.000 **	b	0.039	b	b	1	b
PVL	1.000 **	b	b	−0.463	b	b	1

** Correlation is significant at the 0.01 level (2-tailed). b. Calculation not possible because at least one variable is a constant.

3.5.2. According to Packaging Types

The results indicate that profit is positively correlated with production and marketing costs for 57 kg bags ($R^2 = 0.77$), in 77% of cases. The same applies to the selling price of this packaging type ($R^2 = 0.60$), in 60.2% of cases. These findings suggest that, for 57 kg bags, profit increases in parallel with total costs and selling prices (Table 7).

Table 7. Correlations between profit and key economic profitability parameters, by charcoal packaging type. TC = total costs; SP = selling price.

Variables	Profit	TC 57 kg	TC 43 kg	TC 36 kg	TC 29 kg	SP 57 kg	SP 43 kg	SP 36 kg	SP 29 kg
Profit	1	0.767 **	0.188	−0.337	−0.357	0.603 *	0.651	−0.698	0.325
TC 57 kg	0.767 **	1	−1.000 **	1.000 **	0.583	0.666 *	−1.000 **	1.000 **	0.891
TC 43 kg	0.188	−1.000 **	1	−1.000 **	1.000 **	1.000 **	0.527	1.000 **	1.000 **
TC 36 kg	−0.337	1.000 **	−1.000 **	1	1.000 **	c	−1.000 **	0.529	1.000 **
TC 29 kg	−0.357	0.583	1.000 **	1.000 **	1	0.990	1.000 **	c	0.322
SP 57 kg	0.603 *	0.666 *	1.000 **	c	0.990	1	1.000 **	c	0.998 *
SP 43 kg	0.651	−1.000 **	0.527	−1.000 **	1.000 **	1.000 **	1	1.000 **	1.000 **
SP 36 kg	−0.698	1.000 **	1.000 **	0.529	c	c	1.000 **	1	c
SP 29 kg	0.325	0.891	1.000 **	1.000 **	0.322	0.998 *	1.000 **	c	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). c. Calculation not possible because at least one variable is constant.

3.5.3. According to Sales Season

Our results reveal a positive correlation between profit and the selling price of charcoal during the rainy season (R^2 = 0.90). However, during the same season, no relationship was found between total costs and profit. Similarly, in the dry season, profit was not correlated with either the selling price or total costs. These findings indicate that it is specifically during the rainy season that profit increases in parallel with the selling price of charcoal at the point of sale (Table 8).

Table 8. Correlations between profit and key economic profitability parameters by charcoal sales season. TCRS = total costs in rainy season; TCDS = total costs in dry season; SPRS = selling price in rainy season; SPDS = selling price in dry season.

Variables	Profit	TCDS	TCRS	SPDS	SPRS
Profit	1	−0.120	0.368	0.445	0.901 **
TCDS	−0.120	1	b	−0.280	b
TCRS	0.368	b	1	b	0.419
SPDS	0.445	−0.280	b	1	b
SPRS	0.901 **	b	0.419	b	1

**. Correlation is significant at the 0.01 level (2-tailed). [b]. Calculation not possible because at least one variable is constant.

4. Discussion

4.1. Methodology Used in the Present Study

In the present study, 20 professional charcoal producers in the rural area of Lubumbashi were monitored. The use of this relatively small sample, combined with individual tracking, facilitated consistent data collection from the same producers over an eight-month period, covering the entire production and marketing cycle. This extended observation period enabled the collection of more in-depth and accurate information. Data were collected in real time, and profitability calculations were based on actual market prices throughout the study period. The adopted methodology draws inspiration from kiln-based charcoal monitoring approaches previously applied on the Batéké Plateau and in Yangambi [16]. This research also serves as a continuation of [15], involving the same participants, but this time through an economic and financial lens.

The results are generalizable to all charcoal producers in the rural area of Lubumbashi, since carbonization practices are relatively homogeneous, with traditional earth kilns being widely dominant [14,26]. While some factors may influence yields, differences are mainly observed in production volume, which is linked to the producer's individual skill level [52]. The observed similarities in production practices suggest equally similar behavior in terms of marketing. This homogeneity justifies the generalization of results, especially since the sampling targeted producers who were technically and commercially representative. Professional producers were prioritized due to their regular engagement in charcoal production, their accumulated experience across multiple seasons, and their high output levels—producing at least 40 bags per kiln [15,30].

Data were collected throughout the production and commercialization process, providing a detailed and comprehensive view of charcoal marketing in Lubumbashi and its rural hinterlands. This methodological approach provided reliable, context-specific data for the economic calculations, in contrast to studies that rely on one-time surveys at points of sale [48,51]. The economic and financial analysis—based on the calculation of three profitability indicators (profit, profit margin, and benefit–cost ratio)—helped dispel doubts about the profitability of charcoal production, which has often been debated in previous studies conducted in the same region. The methodology also made it possible to identify the interactions between the various economic variables that influence profitability.

While many studies have been limited to calculating profit or value added—especially in value chain analyses—their findings are consistent with ours in confirming the sector's profitability [14,30]. However, our study goes further by identifying the specific conditions under which this activity becomes more profitable. It also highlights the relationships between economic variables, whereas other studies have opted for broader approaches using predictive statistical models [53,54].

The identification of the economic factors influencing profitability—conducted through multivariate analysis, particularly linear regression and correlation analysis—enabled the isolation of key determinants of profit: namely, selling price, production costs, and marketing costs. This approach proved relevant given the quantitative nature of the variables. The use of the correlation coefficient helped assess the strength of the relationships between variables and measure the specific contribution of each to profit formation, thereby contributing to a better understanding of the profitability mechanisms observed in the charcoal value chain [15,45,46].

4.2. Sales Locations of Produced Charcoal

According to our results, charcoal was sold at different locations. The majority of producers sold their products in the village, followed by sales in Lubumbashi. A smaller number sold directly at the production site. In these cases, transactions occurred between producers and resellers who came to the site themselves. Because resellers bore no transport costs, they were able to purchase charcoal at a lower price. While this arrangement benefits intermediaries, it disadvantages producers, who earn reduced profit margins [55]. Village sales, in contrast, were the most common. They allowed producers to charge slightly higher prices, justified by moderate transport costs between the forest and the village. Transportation was typically performed using bicycles or motorcycles. This strategy enabled producers to marginally increase their profitability compared to sales made directly at the production site.

These observations are consistent with those of [56], who emphasized that various economic factors—including the point of sale—strongly influence charcoal marketing. For instance, in the Kalounayes region of Senegal, some producers preferred to sell informally in order to avoid legal taxes. Similar practices exist in Lubumbashi, where some sellers choose to sell directly from their homes to avoid taxes imposed in official markets and depots. Conversely, in Kinshasa, charcoal marketing is mostly centralized in markets and depots, especially for large bags [9].

Our findings corroborate those of [26], who compared sales practices in Lubumbashi and Kinshasa. They observed that in Lubumbashi, charcoal could be sold in the producers' villages, often along roadsides, as well as in the city. Moreover, Ref. [30] identified the same sales locations, also noting the diversity of actors involved in the charcoal value chain, ranging from producers to resellers, wholesalers, and semi-wholesalers.

4.3. Charcoal Selling Price

Our results revealed that the selling price of charcoal varies depending on the type of packaging. The 57 kg bag stood out with a higher selling price than the other formats. This indicates that using larger bags offers an economic advantage by enabling better market positioning. These findings align with those of [27], who showed that in Benin, roadside sellers opted for 70 to 75 kg bags to attract more customers and increase their profit margins, whereas earlier packaging sizes ranged from 40 to 60 kg.

Similarly, Ref. [26] emphasize that bag size is a key factor in price variability. Smaller bags are sold at lower prices due to weight differences compared to other formats—a dynamic also observed in retail sales in urban areas [30]. A comparable situation was documented in Malawi, where the selling price also varied according to packaging type [57].

The selling price also fluctuates by season. During the rainy season, a slight price increase was observed, although it was not statistically significant. This trend supports the findings of [37], who explained that seasonal variation affects prices: in the dry season, production rises due to improved road conditions, which facilitate supply. In contrast, during the rainy season, supply decreases due to poor road conditions and producers returning to agricultural activities, which impact production and marketing costs. A similar pattern was observed in Ethiopia, where [58] note that charcoal prices vary with supply, with more stable or lower prices during dry periods when production is higher.

Our results also indicate that the selling price increases with distance from the production site. This trend is consistent with the observations of [35] in southwestern Angola, where price increases are recorded in urban centers in proportion to their distance from production zones. This phenomenon can be explained by intermediate costs incurred during product transportation—the greater the distance, the higher the associated costs. As highlighted by [14,44], these costs include transportation, taxes, storage, and other logistical expenses. This situation is strikingly illustrated by [27], who show that in Benin, the cost per kilogram of charcoal can increase by 122% between the production site and the urban market.

4.4. Costs Related to Charcoal Production and Marketing

Our results indicate that the costs associated with charcoal production and marketing in the study area mainly include expenses related to labor, packaging, taxes, handling, and transportation. As noted by [59], charcoal producers face a wide range of expenses throughout the production process. Among these, transportation appears to be the most significant cost item, particularly for delivering charcoal to the city of Lubumbashi. This observation aligns with the findings of [60], a study conducted in Lamim (Brazil), which found that transportation—combined with land access fees and tree acquisition—accounted for up to 82% of total production costs. In parallel, Ref. [28] emphasizes the importance of labor as a key variable influencing carbonization productivity. Labor costs can be substantial due to competition with other rural activities, particularly agriculture [6,61].

Our findings show that total production and marketing costs vary according to the sales location and increase with distance from the production site. This trend is explained by the accumulation of transportation costs, taxes, and other logistical expenses incurred during the delivery process. As highlighted by [34], charcoal gains added value in urban areas due to these additional costs. Indeed, supply basins are often located far from major consumption centers, leading to increased marketing costs [33].

Moreover, our results indicate that production costs do not vary significantly according to the packaging type. This may be due to the fact that producers do not plan their investments based on the number of bags to be produced. Since the yield of a charcoal kiln is difficult to anticipate, costs are incurred before the actual volume of charcoal is known. In addition, transportation fees do not take into account the size or dimensions of the bags. As [14] points out, during wholesale transactions in Lubumbashi, producers face numerous constraints: administrative and police harassment, high fuel costs, frequent vehicle breakdowns, and above all, the increasing distance to supply areas.

4.5. Charcoal Profitability

Our results showed that charcoal production in the rural area of Lubumbashi is generally profitable. The 57 kg bag demonstrated the best economic performance, in terms of profit, profit margin, and benefit–cost ratio. In contrast, the 29 kg bag showed negative profitability, once all production and marketing costs were taken into account. These findings are consistent with the work of [7,62], which shows that charcoal production is an essential source of income for many households, encouraging producers to implement various optimization strategies, such as diversifying packaging types or reducing the number of intermediaries in the value chain.

The low profitability of small bags is largely explained by a selling price that is insufficient to cover total costs. This price is often unstable and does not reflect actual expenditure fluctuations, as observed by [36] in Kinshasa, where large price variations are linked to market realities, particularly the seasonality of sales. A similar situation was observed in the Philippines, where [63] reported negative profits due to the high cost of labor in charcoal production. These results confirm once again the decisive role of the selling price in the profitability of the charcoal value chain. Moreover, Ref. [64] emphasizes the importance of producers staying well informed about prices in urban markets in order to maximize their profits, as also noted by [48,54].

Moreover, when sales are made directly at the production site, it is often the resellers who set the purchase price. As they are the ones who travel to the producers, they hold greater bargaining power. This asymmetry puts producers at a disadvantage, as the imposed price does not always reflect the actual costs incurred during the production process, which can result in economic losses [65].

4.6. Determinants of Profitability Following Charcoal Sales

Our results indicate that profit decreases as production costs increase, especially when sales occur at the production site. This shows that in such contexts, production costs have a determining effect on profitability. This situation is partly explained by poor pricing practices among producers, who do not always take into account the full range of costs incurred. As noted by [48], the failure to factor in actual costs when setting selling prices is a key cause of financial loss, as observed among charcoal producers in northeastern Benin.

Our findings also show that profit increases in proportion to the selling price, regardless of the sales location. This confirms that the selling price is a major driver of profitability. In Uganda, Ref. [66] observed rising selling prices linked to growing urban demand due to population growth, making charcoal production more profitable. Similar trends have been reported in several cities in the Democratic Republic of Congo, where [49] found that profits were higher in Kinshasa than in Kisangani, due to more favorable prices offered by producers in the Kinshasa region.

With regard to the 57 kg bag, our results reveal that profit is influenced by both production and marketing costs, as well as by the selling price. This packaging type requires greater investment, but it also allows for a proportional price increase, leading to higher profitability. This performance is also driven by household preference for larger packaging sizes. According to [67], in Kinshasa, purchasing large bags is more cost-effective than buying small bundles, as it lowers the cost per kilogram. A similar situation was documented in Bamako (Mali), where households favored larger bags for their perceived cost-efficiency [32].

We also identified a positive correlation between profit and selling price during the rainy season. This trend can be explained by higher prices during that period, due to reduced supply. In the rainy season, poor road conditions limit charcoal transportation, while occasional producers—typically farmers—temporarily withdraw from the activity [45,64].

Moreover, Ref. [68] noted in Madagascar that village accessibility directly affects producer income and profit: those located in inaccessible areas earned significantly less than producers in well-connected villages. Similarly, Ref. [69] shows that in the city of Dar es Salaam (Tanzania), supply increases during the dry season, resulting in lower profit margins during that period. Finally, Ref. [70] confirms that irregular supply during the rainy season has a direct impact on prices and, consequently, on the profitability of charcoal sales.

4.7. Implications for the Future of Charcoal Production

The charcoal sector in the Democratic Republic of the Congo faces numerous challenges, particularly those related to regulatory frameworks, poor technical performance, and limited environmental sustainability [71]. The unsustainable exploitation of forest resources further exacerbates the situation [72,73]. Although charcoal marketing holds significant economic potential, its profitability and efficiency could be substantially improved through well-targeted strategic decisions at each stage of the distribution process [74]. However, several persistent obstacles remain, including environmental degradation—which limits producers' access to markets [75]—as well as high transportation, taxation, and labor costs. These factors negatively affect the economic viability of the activity and undermine the livelihoods of producers and their families [72].

In the Lubumbashi region, the progressive depletion of charcoal supply basins due to deforestation [22,23] threatens to make this resource increasingly unaffordable for urban households in the long term. This situation is particularly concerning given that 98% of households in the city rely on this fuel to meet their energy needs [10]. If this trend continues, serious challenges to supply sustainability are likely to emerge.

In this context, the formalization of charcoal production appears to be a key solution for addressing the illegal and unsustainable exploitation of forest resources (Ciza et al., 2015) [71]. The absence of effective forest management strategies, weak institutional commitment to ecosystem protection, and low public awareness of environmental risks all contribute to the persistence of this issue [34].

We therefore propose that charcoal producers organize themselves into formal structures, which could serve as a critical lever for enhancing the sector's sustainability [76,77], while also strengthening both production and commercialization. Such organization would not only facilitate better access to financing [78] but would also allow for the collective regulation of transportation costs, taxes, and pricing, thereby improving producers' incomes [76]. Furthermore, these structures would provide producers with greater representation in the governance of the wood-energy sector, acknowledging the strategic role that charcoal plays in rural development [79].

Although our findings highlight the economic profitability of charcoal production, questions remain regarding the long-term sustainability of this activity within the broader framework of sustainable development, which requires a balance between economic growth and environmental preservation [80]. Carbonization yields remain low due to inefficient techniques [14,15], and in a context where the sector remains largely informal [16,71], producers face the ongoing challenge of reconciling their subsistence needs with environmental conservation goals in order to ensure the sector's long-term viability [81]. This transition should begin with the improvement of carbonization techniques to enhance kiln efficiency, alongside the progressive formalization of the sector. These efforts must be supported by legislation that promotes the sustainable exploitation of forest resources [62,82], as well as by the establishment of formal associations of charcoal producers [29].

Although policies aimed at promoting a sustainable charcoal supply are in place—such as the Forest Code of the Democratic Republic of Congo—this study reveals significant gaps in their implementation. These shortcomings are primarily due to the sector's continued informality and limited outreach efforts [83]. We recommend regular field monitoring by government officials to ensure the effective enforcement of these regulations, and we encourage NGOs and research institutions to strengthen the dissemination of improved carbonization techniques, which are essential to the sustainability of the value chain and the enhancement of producers' incomes. Taken together, these measures would help reduce pressure on forest ecosystems while improving producers' livelihoods, thus paving the way for the sustainable development of the charcoal value chain [63].

5. Conclusions

This study examined the marketing strategies and profitability of charcoal production in the rural area of Lubumbashi (DR Congo), based on the monitoring of 20 professional charcoal producers from production to commercialization. The results show that the majority of producers sold their charcoal in the village (55%), compared to 35% in Lubumbashi and 10% at the production site. Profitability was influenced by several factors, including sales location, season, packaging type, selling price, and both production and marketing costs. The 57 kg bag proved to be the most profitable, whereas the 29 kg bag yielded negative returns, particularly in urban areas, due to inadequate pricing and poorly managed costs. This study also found that profit increased with higher selling prices and declined when production costs were high, especially at the production site. A positive correlation between price and profit was observed during the rainy season. These findings support our hypotheses regarding the influence of marketing strategies and economic variables on profitability.

Although financially profitable, charcoal production by professional producers in the rural areas of Lubumbashi faces significant sustainability challenges, primarily due to inefficient carbonization practices. We recommend conducting in-depth research on improved carbonization techniques, as well as efforts to formalize the sector and better organize producers into associations. These measures would help reduce costs through resource pooling, increase productivity, and improve access to market information. Additionally, the standardization of packaging formats could contribute to more effective market regulation. The role of the state remains critical, particularly in promoting and monitoring the enforcement of existing legislation on wood energy in relation to sustainable development. Such an approach could help reduce pressure on the Miombo forest, while also enhancing the profitability of the activity and the living conditions of producers, thereby ensuring the sustainability of the sector.

Author Contributions: Conceptualization, Y.U.S., J.N.M.F. and J.B.; methodology, N.K.M.; software, N.K.M., H.K.M., B.E.O. and D.-d.N.N.; validation, Y.U.S., J.N.M.F. and J.B.; formal analysis, N.K.M., J.T.K., L.N.N. and F.B.; investigation, N.K.M.; writing—original draft, N.K.M.; supervision, Y.U.S., P.L., J.N.M.F. and J.B.; project administration, Y.U.S. and J.B.; funding acquisition, Y.U.S. and J.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Académie de Recherche et d'Enseignement Supérieur (ARES), Belgium, through the CHARLU Project, a Research and Development Project: "Capacity Building for the Sustainable Management of the miombo woodlands through the Assessment of the Environmental Impact of Charcoal Production and the Improvement of Forest Resource Practices".

Institutional Review Board Statement: Ethical review and approval were waived for this study because the research only involved voluntary, anonymous socio-economic surveys without health-related components. In accordance with national legislation, the establishment of ethics committees is encouraged for public health studies. However, there is no legal requirement for ethical approval for socio-economic studies that do not fall within the medical field.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data related to the present study will be available upon request for any interested party.

Acknowledgments: The authors express their gratitude to all the members of the studied villages for their hospitality, and especially to all the professional charcoal producers in the rural zone of Lubumbashi, who facilitated our data collection. A special thanks go to Arsen, Jerry, and Cosmas for their availability and support in the field during the data collection process.

Conflicts of Interest: The authors declare no conflicts of interest.

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