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An assessment of the economic viability of ecological coffee processing technology in Cameroon

Musebe, R.O.*, Agwanda, C. A., Akiri, M. and Hyacinthe Founsie

CABI Africa, P.O. Box 633-00621, Nairobi, Kenya.

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Coffee is an important crop in Cameroon in terms of income and employment generation. Productivity of coffee has been declining over time with a consequent decline in the corresponding incomes. The Government of Cameroon is addressing this shortfall through a number of measures, a key one being introduction of four pilot central pulping units (CPUs). This paper assesses the technical, economic and commercial sustainability of the CPUs. There was good capacity utilization among all the CPUs as indicated by no significant difference ($p>0.05$) between the model specification and what the CPUs actually achieved. The main approach for increasing capacity utilization is processing more coffee per day, utilizing more days and hours on each processing day. It is possible for the CPUs to perform better under improved conditions of red cherry delivery. All the CPUs except one were commercially viable in the trial phase. The exceptional non-viability was due to management problems, but projections assuming good management demonstrated that it would be commercially viable in the long run. Coffee processed was above the breakeven quantities. Given improvements in the production levels, the cooperatives in charge of the CPUs can purchase the CPUs. Net benefits accruing to the use of the CPUs were higher than those derived from other processing practices. Coffee growers' perceptions, technical efficiency and commercial viability lend support to sustainability of the CPUs. There is need to encourage the coffee growers to increase the supply of coffee to the CPUs. Capacity building is required to improve financial and labour management among the cooperatives that are in charge of the CPUs.

Key words: Processing, technology, benefits, sustainability, efficiency, profitability, pulping.

INTRODUCTION

Coffee is the primary source of cash income for thousands of households in the rural areas and provides livelihoods to many others across the supply chain in Cameroon. The crop generates foreign currency earnings and provides employment to the rural communities. The commodity forms an important income generating activity for smallholder producers, with an estimated 400,000 households, representing about 2.8 million people, deriving their livelihoods from the cultivation of the crop (RoC, 2009b). The bulk of Cameroon's production is

*Corresponding author. E-mail: r.musebe@cabi.org.

Robusta coffee. The ratio of Robusta/Arabica production in the country is currently estimated to be 9/1. The coffee sector's significance and importance in Cameroon has undergone drastic decline since the 1980s when the crop was the largest agricultural export commodity in terms of volume and a primary source of cash income for an estimated 400,000 rural households (World Bank, 2010). Production of the commodity has declined over the last three to four decades from an average of 100,000 metric tonnes annually to just over 40,000 tonnes by 2010 (World Bank, 2010). According to the World Banks (2010), a number of factors contributed to the value and volume of coffee exports from Cameroon. The liberalization of the coffee sector, the steep and prolonged decline in international coffee prices, the collapse of Cameroon's coffee cooperative system, and the rapid entry and exodus of private operators were some of the major shocks experienced by the Cameroon coffee industry over the past 20 years. As a result, coffee production declined from a peak of 146,848 tons in 1987/88 to 31,524 tons in 2007/08. This decline was further accentuated by the poor world prices for the commodity experienced in the mid 80s and early 90s which led to the neglect of coffee farming by the smallholders. The value of exports for the country likewise declined over time, falling from a peak of US$ 302,654,000 in 1980 to about US$ 66,000,000 by 2010 (FAOSTAT 2012).

To address the declining performance of the coffee sub-sector, the Government of Cameroon has put in place initiatives to revive the coffee sub-sector in the country as outlined in the coffee sector development strategy 2010 – 2015 (RoC, 2009b). The initiatives involve the enhancement of both production/productivity and quality of coffee, leading to increased export of high quality coffee and subsequently increased export earnings. One element of these efforts involves introduction of Central Pulping Units (CPUs), whose establishment is meant to contribute immensely to the improvement of the quality of Cameroon coffees.

The Government of Cameroon, with financial support from the European Commission's (EC) All African, Caribbean and Pacific (ACP) Agricultural Commodities Programme (AAACP) and the World Bank, installed four pilot Central Processing Units (CPUs) in the East, North-West, West and South-West regions of the country. The pilot centres are based on small ecological coffee pulping equipment and are aimed at producing high quality fully washed Robusta and Arabica coffees. In addition, the use of the equipment was meant to increase access to improved coffee pulping facilities by the smallholders, reduce the cost of coffee processing, minimise environmental pollution associated with the use of large traditional coffee washing stations and to provide viable alternatives to the hand pulpers commonly used in some parts of the country. Two of the Pilot CPUs were installed in the Arabica coffee areas, while the other two were installed in the Robusta coffee zones. Assessing performance of the CPUs was considered necessary to establish their economic and commercial viability and how they compare with the existing coffee processing practices. This paper reports results and inferences of an economic assessment of the CPUs, an innovative coffee processing technology in Cameroon. The paper proceeds in this endeavour by examining the efficiency, commercial viability and sustainability as well as the farmer perceptions of the CPUs.

LITERATURE REVIEW

Coffee quality is affected by pre and post-harvest practices (Abrar et al., 2014). It is estimated that 40% of the quality of coffee is determined in the field, 40% at post-harvest primary processing, and 20% at secondary/export processing and handling including storage. Primary coffee processing, which is the production of green beans from the coffee fruits is practised to bring out more flavour (Chanakya and De Alwis, 2004). The main methods of primary coffee processing are wet processing, sun-dried (natural) and semi-washed coffee processing. Most of coffee in Cameroon is processed using the sun-dried method. Fully washed Arabica has demonstrated in the previous 3 years to have a market which would pay significant premiums. The small quantity produced readily found markets internationally; though at present produced through classic Coffee Washing Stations (CWS) (RoC, 2009a). Currently there is no production of washed Robusta in Cameroon (RoC, 2009a). This is despite the fact that washed Robusta coffees fetch higher prices in the international market hence present a profitable opportunity in the market for improved Robusta qualities which could be achieved with a modest investment. Production of centrally processed washed Arabica and Robusta coffees should open up new markets for Cameroon coffee (RoC, 2009a). Hitherto, only Arabica coffee is processed using central coffee washing stations (CWS).

The classic CWS require a considerable investment, use high volumes of water, and require a large volume of fresh cherry to run at reasonable capacity utilization. In the case of Belo in North West Cameroon, processing is traditionally done using hand-driven pulpers. Most farmers nevertheless do not have their own pulping facilities, with an estimated 56% renting the equipment (Kuit et al., 2008). Harvested coffee can therefore wait for up to 5 days due to the scarcity of the pulping facilities, with significant negative impact on the quality. Introduction of the modern CPUs was expected to overcome such challenges and hence improve the quality of coffee which subsequently attracts better income.

Modern smaller Central processing units (CPUs) therefore present an interesting opportunity since they are amenable to low throughput operations. They are economically viable with much lower volumes of cherry due to their smaller infrastructure and lighter investment. In addition, they require lower volumes of water, using typically 10 – 20% of the water required in a classic CWS (Gonzalo et al., 1995; Ulf, 2004; Cornelius, 2011). This is due to the mechanical removal of mucilage, which eliminates the need for fermentation and washing associated with the classic CWS. This greatly simplifies and speeds up the processing. Less infrastructure/construction – and therefore less investment – is required. It is reasonable to expect 20 – 30% uplift in the value of the finished product, due to its better primary processing and drying.

Smaller modern central processing units (CPUs) using ecological pulpers with mechanical mucilage removers are being piloted in Cameroon. This ecological coffee processing technology is meant to increase the quantity of quality coffee processed and hence the earnings of the coffee growers. Establishing the viability of such technology is necessary to assure continued investment and use. Agronomically and economically sustainable coffee production is feasible by applying best practices of crop production and post-harvest processing (Vossen, 2005). Coffee production practices have been used effectively in their different forms but the processing activities have not exploited the full range of methods in Cameroon. This justifies the need for using small modern CPUs as viable alternatives to the different coffee processing methods.

Studies in Rwanda and Ethiopia revealed that putting in place coffee washing stations, which are necessary to produce high quality coffee, could contribute positively to improving coffee productivity at the farm level (Murekezi, 2003). This line of thought supported the need to examine the economic viability of the CPUs, which would contribute to the coffee growers' incomes and the drive to increase coffee productivity. The key drive towards the use of CPUs is the reduced costs of coffee processing. This is due to the fact that globally the growing demand for specialty or sustainability coffee with the associated premium prices should serve as incentive for coffee washing stations to reform (Kazoora, 2011). However, it is imperative that the premium prices trickle down to farmers as well to encourage improved production at the farm level. This is in line with Cameroon's National Strategic Plan for Coffee which was officially adopted by the Government of Cameroon in 2009. The strategy envisages improved exports and export earnings based on a quality platform (RoC, 2009b). From a functional point of view, the ecological pulpers are amenable to a variety of production levels and can therefore be installed to service a small number of smallholders without the risk of running the equipment under capacity (Gonzalo et al., 1995; Ulf Kusserow, 2004). This can increase the proximity of the CPUs to the smallholders thereby reduce the cost and effort required to deliver cherry to a wet processing plant, hence encouraging the subscription of the smallholders to the CPUs. Success in this endeavour requires a clear appreciation of the financial implications of using the technology. This is because the coffee growers are rational and would not engage in the use of technology that does not generate the necessary financial returns. Use of the CPUs is expected to be more environmentally sustainable as well as bringing added value to the producers. It would also add to the pool of improved wet processing technologies in Cameroon. Success in all respects would be determined by the viability of the technology, which is the thrust of this paper. Marketing of the good quality coffee can be an issue that could interfere with the viability of such a technology. Farmers can raise their productivity and improve their processing skills but if there is no market for their coffee at better prices, then they will revert to selling dried cherries. The CPUs in Cameroon had an associated marketing component where the owners were linked to prospective buyers of the coffee. The question that arose in this regard is whether the assumed incomes pegged on the costs of the technology would be consistent with sustainability endeavours.

MATERIALS AND METHODS

The assessment involved aggregating monetary values of the benefits and costs to the CPUs which were then compared with those of the conventional coffee processing methods in order to establish whether the CPUs are worthwhile (Watkins, 2006). This was undertaken by comparing the difference between the situation in the study area with and without the CPUs as well as assessing the cost effectiveness of operating the CPUs. Costs and benefits for existing processing methods as well as those for the CPUs were computed and the net benefits compared to establish the efficiency of operating the CPUs (Ostertag and Wheatly, 1995; Ferris et al., 2001; Gittinger, 1984). The analyses involved evaluating the CPUs against the existing coffee processing systems in order to assess their competitiveness and prospects for sustainability.

Structured data collection checklists were used to gather data from each of the CPUs. The data included direct operating costs such as labour costs, repairs and maintenance costs, fuel costs, transport costs, farmer perceptions about the CPUs, numbers of growers supplying coffee to the CPUs, coffee prices and coffee sales. Data were collected in West Region (Bandjoun CPU) and North West Region (Belo CPU), which are the regions involved in the production of Arabica coffee as well as the South West Region (Chede CPU) and East Region (Angossas CPU) that are involved in the production of Robusta coffee. Data collected were analysed using descriptive statistics.

RESULTS AND DISCUSSION

Pilot Central Pulping Units

The analysis involved four pilot CPUs. During the 2011/2012 coffee harvesting season, one CPU was

Table 1. Pilot CPUs involved in the cost–benefit analysis, 2011/2012.

Pilot site	Name of CPU	Type of coffee processed	Parchment processed (Kg)
West	Bandjoun	Arabica	12,000
North West	Belo	Arabica	9,500
South West	Chede	Robusta	18,750
East	Angossas (GIC)	Robusta	4,600

installed in each of the pilot sites (Table 1). The Cooperatives and the Groupement d'Intérêt Commun (GIC) which own the CPUs are legally constituted under the laws governing the cooperative movement in Cameroon.

Capacity utilization and operating efficiency of the CPUs

According to the model specification, the estimated capacity of the pulping and mucilage removing machine was 400 kg of cherry per hour for the CPUs installed in Bandjoun and Belo. Working for 6 h per day for 60 pulping days in a season; this translates to 2400 kg cherry per day that gives a total of 144,000 kg cherry per season which is equivalent to 28,800 kg of green coffee (assuming a conversion ratio of 5kg cherry to 1kg green coffee). In the case of Angossas and Chede the estimated capacity of the pulping and mucilage removing machine is 800 kg cherry per hour, working for 6 h per day for 60 pulping days in a season. This translates to 4,800 kg cherry per day that gives a total of 288,000 kg cherry per season, which is 57,600 kg of green coffee.

The efficiency of operating the CPUs is determined by capacity utilization, quality of coffee processed and the maintenance requirements. For purposes of this study efficiency was assessed based on capacity utilization. Capacity utilization achieved was 26.4, 33.3, 6.4 and 20.8% for Belo, Bandjoun, Angossas and Chede respectively (Table 2). In all the cases, the CPUs operated for less than 6 h per day. Only Chede and Belo operated for the stipulated 60 days during the 2011/2012 coffee campaign. This was due to repeated down time resulting from breakages of the CPUs in all the pilot sites except Belo. In addition, inadequate supply of cherries from the coffee growers made it impossible to pulp 2,400 kg per day for CPUs in the Arabica sites and 4,800 kg per day for Robusta CPUs as per the manufacturers' indicated capacity. There was also late access to funds for purchasing the red cherries from the farmers in Belo and Angossas. Low season due to the biennial nature of coffee, as well as farm gate competition with middlemen and the need for the farmers to hold against risk given that this was a new innovation, also contributed to less cherries being processed. Not all the coffee growers supplied their coffee to the CPUs. Those who supplied coffee to the CPUs only gave a fraction of the coffee that they produced to the CPUs. Long distance to the CPUs, lack of transport and high cost of transport also interfered with processing capacity.

Increasing capacity utilisation is expected to result into a concomitant increase in net profit to the CPUs (Table 2). For the Arabica producing sites for example, the rate of increase in the net benefits resulting from a rise in capacity utilisation from 50 to 75% is estimated at 63% in Belo and 65% in Bandjoun.

Similarly, the rate of increase in the net benefits resulting from a rise in capacity utilisation from 50 to 75% for Chede is estimated at 69% compared to that of Angossas (67%). Enhanced capacity utilisation should therefore be a key consideration when installing new CPUs. This can be achieved through moral persuasion to catalyse the growers to supply more cherry coffee to the CPUs. To facilitate this process transport of the red cherries from the coffee farms or designated collection points to the CPUs will be required. Timely access to funds for purchasing cherry is equally critical in fostering better capacity utilisation at the CPUs. The CPU at Belo for instance, could have registered better capacity utilisations if cherry finance became available at the onset of the coffee harvesting season.

Reaching 100% capacity utilisation will require greater discipline in the CPU management. Timely maintenance and repairs of the CPUs will have to be guaranteed in order to reduce machine down time. Arrangements should also be made for work on shifts, especially in case more coffee than can be processed in the day is made available. Capacity building in good agricultural practices, proper management of cooperatives and timely access to funds to purchase the red cherries as well as efficient operations of the CPUs are crucial.

A comparison of capacity utilization based on manufacturer's specification (Table 2) and that based on actual number of days that the CPUs processed coffee (Table 3) shows that they are not significantly different ($t_{0.025}$ = 1.47, p>0.05). This comparison indicates that a key approach to achieving capacity utilization is processing more coffee per day and at the same time utilizing more hours for processing on each processing day as well as more processing days. The farmers also need to increase coffee deliveries to the cooperatives. This can be achieved by increasing production and

Table 2. Effect of capacity utilisation on the net benefits for the four CPUs in Cameroon.

Name of CPU	Expected green coffee (kg) at 100% capacity utilization	Green coffee (kg) at various capacity utilizations	Capacity utilization (%)	Net income (CFA) at current price of green coffee
Belo	28,800	7,600	26.4*	6,264,626
	28,800	14,400	50	15,102,226
	28,800	21,600	75	24,671,026
	28,800	28,800	100	34,239,826
Bandjoun	28,800	9,600	33.3*	8,199,428
	28,800	14,400	50	14,566,471
	28,800	21,600	75	24,034,471
	28,800	28,800	100	33,502,471
Angossas	57,600	3,700	6.4*	-2,349,959
	57,600	28,800	50	11,431,696
	57,600	43,200	75	19,337,296
	57,600	57,600	100	27,242,896
Chede	57,600	15,000	26.0*	4,462,002
	57,600	28,800	50	12,692,252
	57,600	43,200	75	21,274,652
	57,600	57,600	100	29,857,052

Note: * depicts achieved capacity utilization. Current price is 2400 CFA /kg for Arabica and 1200 CFA/kg for Robusta processed through the CPUs;1 US$ = 500FCFA.

Table 3. Coffee pulped, actual number of days worked and capacity utilization.

Name of CPU	Days worked		Coffee pulped (kg)		
	Projected	Actual	Projected based on 6 hrs. per day for 60 days	Actual	% capacity utilization
Angossas	60	35	33,600	3,700	11.1
Chede	60	60	57,600	15,000	26.0
Bandjoun	60	47	22,560	9,600	42.6
Belo	60	61	29,280	7,600	25.9

productivity of coffee by being proactive in the use of good agricultural practices. Under the aforesaid circumstances the technical optimum envisaged based on the manufacturer's specification for the machines can be realised with the associated benefits to the CPUs and members of the cooperatives.

Commercial viability of CPUs

The commercial viability of the CPUs was assessed based on the costs and benefits of the CPUs and was determined by the ability of the CPUs to generate returns in excess of what is required for operation and maintenance. The disaggregated variable costs considered were storage costs, maintenance and repair costs, operation and water costs (Table 4). Other costs are for wire mesh, sacks/bags, drying materials, labour costs for loading into the CPUs and drying costs. Fixed costs are those associated with the equipment purchase and installation (Table 5).

In the assessment of commercial viability; fixed costs arising from investment in the CPU are computed for each year as a derivative of investment costs using straight line depreciation. Assuming a useful life of 5 years and zero salvage value the corresponding fixed costs are 3,839,079 CFA, 3,215,374 CFA, 3,764,734 CFA and 3,952,548 CFA for Bandjoun, Belo, Angossas and Chede respectively.

A comparison of gross income (Table 6) and total costs for each of the CPUs (Tables 4 and 5) shows that Bandjoun, Belo and Chede are commercially viable with positive net benefits of 8,199,428 CFA; 6,264,626 CFA; 4,462,002 CFA respectively. Angossas is not commercially viable at the current level of capacity utilization. It made a loss of 2,349,959 CFA. This is possible because Angossas operated for only 35 days out of the expected 60 days and even then the turnover was marginal. Out of

Table 4. Costs of running the Pilot CPUs (FCFA).

Description of cost item	Belo	Bandjoun	Angossas	Chede
Fixed costs				
Manager	360,000	416,000	239,770	225,000
Accountant/ clerk	180,000	0	0	70,000
Technician	100,000	114,450	325,000	90,000
Store keeper	180,000	0	0	75,000
Security guard	0	0	50,000	60,000
Total fixed costs	820,000	530,450	614,770	520,000
Variable costs				
Labour (drying, grading, fermentation, etc.)	0	179,250	0	167,500
Maintenance & repairs	120,000	121,800	77,350	180,000
Operation (fuel, electricity, etc.)	120,000	509,993	195,500	540,000
Storage (labels, bags, drying, etc.)	240,000	0	0	318,700
Overhead and other costs	0	0	257,605	154,250
Quantity of water (costs)	60,000	0	30,000	132,400
Other costs	0	0	0	572,600
Total variable costs	540000	811,043	560455	2,065,450
Total cost	1,360,000	1,341,493	1,175,225	2,585,450

1 US$ = 500FCFA.

Table 5. Investment/ fixed costs for the CPUs (FCFA).

Description	Bandjoun	Belo	Angossas	Chede
Ecological pulping unit	4,626,250	4,626,250	4,851,250	4,851,250
Shipping charges	112,500	112,500	137,500	137,500
Delivery in-country (air freight)	1,530,000	1,530,000	1,802,500	1,802,500
Customs and transit	198,500	198,500	198,500	198,500
Delivery to CPUs site	411,000	616,500	381,000	570,000
Site Constructions*	12,317,146	8,993,120	11,452,920	12,202,988
Total	19,195,396	16,076,870	18,823,670	19,762,738

1 US$ = 500FCFA. * Constructions costs include drying tables, generating set, cables and electrical, installation, water pump, small building, trays, construction costs, and installation.

a total of 850 active members only 68 supplied red cherries to the CPU. This may be explained by limited group cohesion and low appreciation of the benefits expected from the CPUs. Such a scenario exists where there are management and leadership issues. In this case leader-ship problems may have contributed to this situation. Good leadership is expected to encourage group cohesion which would give confidence to the members to work as a team. The kind of leadership in Angossas does not warrant investment in CPU for the cooperative. If management is improved and more coffee growers supply coffee to the CPU it is possible for it to become commercially viable. Given the understanding that members of the cooperatives would be given a bonus after the sale of the processed coffee it is in principle beneficial for the coffee growers who process their coffee using the CPUs in terms of monetary returns and the time saved that is used for other activities.

The variable costs per kg of green coffee equivalent from the Arabica CPUs were an average of 1,085 CFA for Bandjoun and 1,071 CFA for Belo compared to 1,022 CFA for ordinary pulped coffee. The variable costs for the CPUs are higher than the costs of the conventional processing methods using hand pulpers. However, price per kg of green Arabica Coffee equivalent (2,400 CFA) from the CPUs is more than the price (1800 CFA) from ordinary pulped Arabica Coffee, which indicates that it is more profitable to undertake Arabica Coffee processing using the CPUs compared to the existing traditional processing using hand pulpers. The comparison is made

Table 6. Processing and sales of parchment/ green coffee from the CPUs.

Description of variable	Name of the Central Processing Unit (CPU)			
	Bandjoun	Belo	Angossas	Chede
No of Active members	3,500	5,000	850	150
Average cherry yield per grower per year (Kg)	945	522	1,375	1,760
Expected cherry (KG) - 100% growers supplying	3,307,500	2,610,000	1,168,750	264,000
Actual cherry purchased (kg)	48,300	37,000	18,500	70,000
Price of cherries (CFA/kg)	200	200	100	100
Total cost of cherries (CFA)	9,660,000	7,400,000	1,850,000	7,000,000
Other variable costs (CFA)	811,043	540,000	560,455	2,065,450
Total variable costs (CFA)	10,471,043	7,940,000	2,410,455	9,065,450
Variable cost per kg of green coffee (CFA)	1,091	1,045	651	604
Parchment processed	12,000	9,500	4,600	18,750
Green coffee sold (kg)	9,600	7,600	3,700	15,000
Price per kg of green coffee (CFA)	2,400	2,400	1,200	1,200
Gross income from green coffee (CFA)	23,040,000	18,240,000	4,440,000	18,000,000

1 US$ = 500FCFA.

on assumption that both the conventional method and the CPUs will process the same amount of red cherries that would have been purchased at the same price.

For the Robusta processing the variable costs of the CPUs are higher than the costs for traditional processing of coffee; that is an average of 651 CFA per kg of green coffee in Angossas and 604 CFA per kg of green coffee in Chede; compared to an average of 519 CFA per kg of green coffee equivalent from growers' current processing practices. The comparison is made under the assumption that coffee which is sun dried is purchased at 100 CFA per kg and both methods process the same amount of red cherries. Price per kg of green Robusta Coffee equivalent (1,200 CFA) from the CPUs is more than the price (800 CFA) from traditional processing of Robusta Coffee. This indicates that it is more profitable to undertake Robusta Coffee processing using the CPUs compared to the existing traditional processing by sun drying.

Amortization of the CPUs

In the event that the cooperatives that own the CPUs wish to purchase additional CPUs based on capacity and quantities of red cherries that the coffee growers would be willing to supply, it would be necessary to compute the repayments. This being an agricultural project the suggested repayment should be in terms of annual instalments. The interest would be computed on unpaid balance and there would be level payments. In the computation of level (equal) annual payments the formula specified below is used (Gutierrez and Dalsted, 2007; Lee et al., 1988).

$$Annual\,instalments = Initial\,investment\,[\frac{i}{1-(1+i)^{-n}}]$$

Where i = commercial interest rate
n= period over which the initial investment is to be repaid in years

Computing the average benefits for different capacity utilization of the CPUs and using the initial investment costs; and a commercial interest rate of 20% the Arabica CPUs would be repaid in a period of 4 years at the current capacity utilization. If capacity utilization is improved it is possible to repay in a shorter time. For instance at a capacity utilization of 75%, repayment would be in 1 year for Bandjoun and Belo respectively (Table 7). Angossas will have repayment problems if they decided to purchase a CPU at the current capacity utilization. If management is improved and more members supply red cherry to Angosssas, it is possible to repay for the CPU if the cooperative is interested in buying one. For instance if capacity utilization in Angossas is increased to 75% it is possible to repay for the CPU in 2 years. At the current capacity utilization Chede would repay within a period of 12 years. Increasing capacity utilization to 75% would enable repayment in 2 years for Chede. At 100% capacity utilization all the CPUs can repay in a period of 1 year and use the remaining useful years of the equipment for generating profits for their own use. This means that use of CPUs can be adopted with better benefits for both Arabica and Robusta coffees.

Table 7. Amortization for the different CPUs (FCFA).

Description of variables	Bandjoun (43% utilization)	Bandjoun (50% utilization)	Bandjoun (75% utilization)	Bandjoun (100% utilization)	Belo (26% utilization)	Belo (50% utilization)	Belo (75% utilization)	Belo (100% utilization)
Initial investment (CFA)	19,195,396	19,195,396	19,195,396	19,195,396	16,076,870	16,076,870	16,076,870	16,076,870
Annual interest rate (%)	20	20	20	20	20	20	20	20
Benefits from CPUs utilization	8,199,428	14,566,471	24,034,471	33,502,471	6,264,626	15,102,226	24,671,026	34,239,826
Repayment period years	3.5	2	1	1	4	2	1	1
Description of variables	Angossas (11% utilization)	Angossas (50% utilization)	Angossas (75% utilization)	Angossas (100% utilization)	Chede (21% utilization)	Chede (50% utilization)	Chede (75% utilization)	Chede (100% utilization)
Initial investment (CFA)	18,823,670	18,823,670	18,823,670	18,823,670	19,762,738	19,762,738	19,762,738	19,762,738
Annual interest rate (%)	20	20	20	20	20	20	20	20
Benefits from CPUs utilization	-2,349,959	11,431,696	19,337,296	27,242,896	4,462,002	12,692,252	21,274,652	29,857,052
Repayment period years	Unable to repay	4	2	1	12	4	2	1

1 US$ = 500FCFA.

Farmers' perceptions of the CPUs

Assessment at each of the CPUs revealed that farmers were interested in supplying coffee to the CPUs and were willing to form other associations that would request for other CPUs to avoid congestion in the ones already installed. There were no limits on the number of members that would belong to each of the CPUs. It is expected that the membership would increase or be maintained at the initial level but this is an issue that will require to be checked over time given cooperative sustainability, governance, distance of the coffee growers from the CPUs, as well as changing coffee production and sales scenarios. This means that efforts to assure sustainability of the cooperatives need to be effected. Among these are increased production and productivity of coffee.

The coffee growers in the different regions indicated that they were aware of the central processing units (CPUs). According to the farmers, adoption of the CPUs would reduce the work load of drying coffee. This is because after harvesting; the red cherries would be transferred to the CPUs and farmers would have time for other activities. Alternatively the producers expect that use of the CPUs would produce high quality coffee, which would generate more farm income and hence generate more benefits for the farmers. Farmers noted that they would not be able to effectively utilize the CPUs due to a number of reasons. The CPUs were located far away from the coffee growers and were relatively few in number. Poor road network interfered with the coffee growers' efforts to effectively deliver red cherries to the CPUs.

The coffee growers reported that they would be interested in owning the CPUs and would contribute to the maintenance of the CPUs through delivery of red cherries and pooling of resources for use in repairs and payment of the operators. Farmers were willing to pay processing fees so long as these would be deducted from the proceeds of their coffee sales and not direct payments. Farmers expected that even after the deductions there should be reasonable net benefits to justify selling coffee to the CPUs. There was preference for the modern small CPUs compared to other coffee processing methods.

Table 8. Shut down prices for different CPUs.

Name of CPU	Shutdown price (CFA/ kg)
Bandjoun	1,388
Belo	1,446
Chede	1,081
Angossas	1,044

1 $ = 500FCFA.

Sustainability of CPUs

Sustainability of the CPUs is determined by a combination of factors such as operational efficiency, commercial viability and farmers' acceptance of the processing technology. This involves an assessment of the farmers' perceptions of the CPUs and their willingness to supply coffee to the CPUs. It is also determined by the buyers' preference for the coffee processed by the CPUs compared to the other processing methods. Given the growers' preference for the CPUs it is apparent that they will be sustainable in the long run.

Discussions with the coffee growers revealed that a key reason for the growers' preference for the CPUs is that they reduce the labour required for drying the coffee, thereby releasing labour for use in other activities. The CPUs require less water, meaning that they could be used in a wide range of areas. The Arabica CPUs bought red cherries at 200 CFA per kg which converts to 1000 CFA per kg of green coffee. The processed coffee was sold at 2400 CFA per kg. The difference in the prices is expected to cater for the processing costs and other maintenance and operation costs including payment for skilled and unskilled labour as well as generate profits for the cooperatives.

Break-even analysis was carried out to determine the quantity below which pulped coffee processing would become unprofitable in the context of sustainability. The analysis was conducted using the prices given for green coffee equivalent to compute break-even amounts. The break-even quantity was obtained using the formula:

$$Q = \frac{FC}{P - VC}$$

Where: Q = quantity of green coffee in kg needed to breakeven

FC= fixed costs

P = price per kg of green coffee

VC= variable costs per kg of green coffee

The price per kg of green coffee equivalent was 2400 CFA and 1,200 CFA for eco-pulped Arabica and Robusta coffee respectively compared to 1600 CFA and 800 CFA for Arabica and Robusta coffee processed using the conventional methods. The variable costs per kg of green coffee from the CPUs were computed from data obtained from each of the CPUs and are given in Table 4. Using the formula above, the breakeven quantity is computed based on the fixed costs (Table 5) on the understanding that the useful life of the CPUs is 5 years with a salvage value of zero and straight line depreciation is used. The number of units of green coffee needed to break-even is given as 3,337kg for Bandjoun, 2,978 kg for Belo, 7,509 kg for Chede and 7,984 kg for Angossas.

The average quantity of parchment processed by each of the CPUs was as indicated in Table 6. The maximum quantities of parchment expected to be processed according to the manufacturer's specifications for the Arabica CPUs is 144,000 Kg, which translates to 28,800 kg of green coffee for each of the CPUs and 288,000 Kg for the Robusta CPUs which translates to 57,600 kg of green coffee for each of the CPUs. The breakeven figures mean that for sustainability purposes the minimum amounts of coffee to be processed are 3,337, 2,978, 7,509, and 7,984 kg of green coffee for Bandjoun, Belo, Chede and Angossas respectively. High volumes of pulped coffee produced in some cases show that potential exists and that all farmers can benefit given timely start of processing using the CPUs. In this initial case, Angossas processed quantities that were less than the breakeven quantities. Other CPUs processed coffee well above the break even quantities and made profit in this initial instance.

Actual quantities of green coffee equivalent produced by the CPUs (Table 6) indicate that they are financially sustainable and can improve on sustainability in terms of processing given the cherry production levels by the coffee growers. Given improved capacity utilization Angossas is also financially sustainable.

Sensitivity analysis reveals that CPUs that process relatively less eco-pulped coffee would require higher prices to able to breakeven, while those that process more would require lower prices to breakeven. When the variable costs are reduced below the current levels, it is possible to break even at relatively lower quantities of processed coffee. Higher prices may not be tenable given the current marketing system.

For the CPUs to operate over the long run, they must be able to cover both fixed and variable costs. Thus at full capacity utilization and current variable and fixed costs, prices below the levels specified in Table 8 would lead to shut down, that is closure of the CPUs. Below the stated prices, the CPUs will be of no good to the cooperatives.

For sustainability purposes, farmers will have to produce greater quantities of cherries and the CPUs will need to process more coffee. There would be need for relatively high prices in the cases of less coffee being processed. Since prices are volatile, there is need to assure improvements in production, productivity and deliveries to the CPUs. Efficiency in production should be considered for purposes of increasing incomes after the break-even levels have already been achieved, using the recommended production and processing practices. Given the limited control over prices, it is necessary for the CPUs to strive to process as much coffee as possible coupled with cost reduction measures. These include efficiency in finance and labour management. There is potential for production of higher volumes of eco-pulped coffee, as attested to by the maximum quantity of red cherries that could potentially be delivered by all growers expected to supply the respective CPUs. If the full coffee production from all the coffee growers is exploited, there will be need for more CPUs in all the pilot project areas and beyond depending on interest of the other coffee growers.

However, there are some challenges to the sustainability of the CPUs that need to be addressed. Among these are marketing of coffee by the respective CPUs, labour and financial management, water shortage, electricity and maintenance of the CPUs. With regard to marketing, there is an agreement between the groups that own the CPUs and coffee buying agents to purchase the coffee. The CPUs reported that water shortage was a challenge to sustainability. Water supplied was inadequate for processing purposes in some CPUs. The water sources supplied less water. Water limitation may be addressed by ensuring that there is adequate water storage capacity for processing purposes.

Maintenance of the CPUs and supply of electricity posed another challenge. In some instances the generators broke down unexpectedly. All these underscore the need for proper maintenance to forestall breakdown of the CPUs, which could interfere with the processing activities. Labour and financial limitations were also reported as constraints in the use of CPUs. Marketing of coffee processed by the respective CPUs, management of the CPUs and technical know-how are some other issues that require consideration. This in essence calls for training in order to build the requisite capacity, and assuring access to production and marketing information.

Conclusion

The CPUs achieved good financial viability, which means that the CPUs are commercially viable, except Angossas, at the current levels of processing. Even then, Angossas can still breakeven if costs are reduced and/or more capacity utilization is achieved. The CPUs processed coffee beyond the breakeven quantities indicating relatively good profitability for the current operation levels. The breakdowns in some of the CPUs point to the need to put in place proper mechanisms for maintenance of the CPUs, user efficiency and more versatile machines. Managers of the CPUs as well as the team in charge of the cooperatives require training to assure efficiency in operations. There is high potential for improving profitability, given the coffee production capacity of the members of the cooperatives that were supplied with the pilot CPUs. Thus, as the CPUs continue processing more coffee, better positive returns would be achieved.

The breakdowns in some of the CPUs point to two issues: (i) Prior assessment of suitability of the processing equipment to be installed in the CPUs is crucial. In particular, the equipment should have acceptable level of durability and versatility to reduce disruptions during the processing season arising from mechanical breakdowns. Local availability of service parts is also an important element when considering the use of a given type of CPU equipment on a larger scale. (ii) There is need to have a pool of artisans with experience in the installation and repair of the CPU equipment. Consequently, in addition to the training offered to the CPU machine operators, deliberate training should be given to the local artisans with whom the parent producer organisation hosting the CPU have working relations. In many instances, the cooperatives have in-house mechanics. These should also be a target of training on the installation and repair of the CPU machines.

Technical efficiency achieved in this initial campaign is commendable, given that this is a new technology that would require some time for adoption of the practices. The reasons leading to the indicated performance can be addressed during subsequent years of operation of the CPUs. Cooperative members need to be enlightened about the need to sell their red cherries to the CPUs, and on the other hand the CPUs require funding for purchasing the red cherries. Interested stakeholders including the government should be sought. Depending on the financial base of the cooperatives and level of trust, some CPUs may obtain red cherries on credit from the coffee growers. Repairs and maintenance of the CPUs need to be conducted in time, meaning that proper links should be established with all those involved in undertaking the repairs and maintenance.

The reported initial profitability and technical efficiency levels coupled with the growers' interest and commitment indicate that the CPUs would be sustainable in the long run. Profitability and technical efficiency may be improved further through capacity building in terms of training and financial support to the cooperatives. Quality of coffee from the CPUs was rated better compared to coffee from sun dried processing. Quality and quantity of coffee processed would improve in the future as the new processing method gets entrenched in the current system. The quality of green coffee would improve following improvements in post-harvest handling as well as operation of the CPUs. This would translate into higher incomes for the participating cooperative members who would serve as examples to encourage others to get involved in processing using the CPUs.

Improvements in the cooperatives management to assure better access to markets, efficient sales and better treatment of the cooperative members is also necessary. This requires structured capacity building activities for leaders of cooperatives and their members in order to promote better governance. Additionally, proper financial management is another area where capacity building will be necessary. The objective is to promote better access to credit from commercial banks through better governance and financial viability of the cooperatives. There is also need to create awareness among the farming community regarding the benefits associated with the use of the CPUs to process their coffee as compared to home processing using hand pulpers or selling cherries to middlemen. The objective is to improve on the capacity utilisation of the CPUs, reduce the marginal cost associated with producing coffee through the CPUs and hence increase profitability. The importance of improving coffee productivity and quality of cherry should also be emphasized during the sensitisation and awareness creation sessions. This can be achieved through field days, using the mass media and meetings of the cooperatives and other stakeholders in the coffee sector.

Conflict of Interests

The authors have not declared any conflict of interests.

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