



Research Article

Pre-Extension Demonstration and Evaluation of BAERC Model Engine Driven Coffee Dehuller in East Wollega Zone, Ethiopia

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Abstract

Coffee agriculture is critical to the Ethiopian economy, with around a quarter of the people relying on it directly or indirectly for survival. Yet there are still problems associated with the way coffee is currently processed that underscore the need for mechanized alternative capable of improving efficiency, preserve coffee quality and boost smallholder income. Cognizant of this engine operated coffee dehuller was demonstrated with the specific objectives of enhancing farmers' awareness of coffee dehuller, evaluating its performance, and assessing participant stakeholders' feedback. The participants were determined through purposive sampling out of the households residing in Gammachis and Falamo-Yubdo kebeles. Data were gathered focus group discussions, measurement and observation and were analyzed adopting simple descriptive statistics. The result revealed that total cost of operation for coffee dehulling by BAERC coffee dehuller were found 77% cheaper than the traditional method of dehulling done by woody pestle and mortar, The saving in time also 89.58 in percent. This result could typically support the conclusion that adoption and use of demonstrated dehuller. Therefore, the machine was recommended to scaling up and diffusion for greater impacts.

Keywords

Coffee, Coffee Dehuller, Demonstration, Operating Cost, Mortar and Pestle

1. Introduction

Agriculture in Ethiopia remains to be the key sector while industrialization and services continue to expand. It is still the major share contributor to the total GDP (32% or so), the largest labor force employer (about 64%), the main source of foreign exchange earnings (up to 79%), and is also still regarded as the key pathway out of poverty [11]. Nonetheless, more than 90% of the country's agricultural output is generated from smallholder agriculture that undertaken on an average holding size of less than one hectare with low average productivity ranging

from 200 to 250 kg/ha [1, 15].

Within the agricultural sector, the coffee sub-sector is vital to Ethiopia's economy and foreign exchange balance, representing an average of 5% of GDP, 10% of total agricultural production, and 24% [10] of export earnings—30% to 35% by other estimates [17]. All Ethiopian production is Arabica type that supports directly or indirectly the livelihood of some 15 million people [9] including smallholder farmers and other market players involved in various stages of the coffee value

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chain.

Currently Ethiopia is Africa's top and world's fifth largest coffee producer just behind Brazil, Vietnam, Colombia and Indonesia [10]. The land area under coffee cultivation is difficult to determine because plots are fragmented and interspersed with other crops. It is estimated, however, that Ethiopia has over 760,000 hectares of coffee area in 2024 cropping year [2]. Small private coffee plantations contribute about 90% of the country's coffee, while large state-owned plantations account for the rest. Total production of coffee is about 688,000 MT mainly concentrated in the four states of Oromia, Sidama, South-West and South Ethiopia. According to [4], the Oromia region contributes the largest share of Ethiopia's coffee production, accounting for approximately 59% of the total output. This is followed by the Sidama and South-West Ethiopia regions, each contributing around 13%, and the South Ethiopia region at 8%. The remaining production comes from Central Ethiopia (4%) and other regions (3%). In the same year, exports amounted to about 2000 tones. Coffee in Ethiopia is not just a crop; it is a cultural cornerstone that has shaped the nation's history, society, and global relations. Even the word "coffee" is reportedly derived from the "Kaffa" region in which it was first grown [6, 13].

Despite its importance, the coffee sector continues to face challenges such as low productivity, impoverishing of quality, price volatility, changing regulatory frameworks, and inadequate infrastructure and limited access to finance. The main root causes of poor quality in green coffee beans can be attributed to various factors throughout the coffee production and post-harvest stage [12].

Efforts are already underway to address these challenges and still government of Ethiopia has been encouraging private individuals, farmers' cooperatives or state enterprises to invest in machinery which they hope will lead to the expansion of large-scale commercial plantations and improved quality and productivity. So, nowadays, there are more than 1000 coffee cherry processing plant in the country, with approximately 492 hulleries and 601 washing stations. Yet they are not feasible for small capacities as they require high-volume minimums and may not be located close to the farm, increasing transportation costs.

As a result, small holder producers in the most remote areas have no choice but to sell red cherry coffee on their farm or continue to dehull their valuable product using mortar and pestle. Such traditional dehulling of coffee is a time consuming, labor intensive, but important task performed by women in rural areas of the country. As noted in [8], with this dehulling practice, kernel damages in the form of bruises that in turn facilitates the infestation of pests during storage, are not inevitable. Abrading hulls from dry coffee like this, affects the final cup quality and deteriorates flavor, fragrance and other attributes of coffee as well, as indicated in the study conducted by Dagnachewu [3].

Hence to give quick-solution for the problem abovementioned, a powered coffee dehuller was adapted, fabricated at

BAERC and tested in terms of dehulling capacity, percentage of breakage and dehulling efficiency. From the test conducted, performance of the dehuller was found best with the average dehulling capacity range of 155.5-184.7 kg/hr. The decortication efficiency and breakage percentage of the adapted coffee dehuller were observed in the range of 93.80-99.36 and 0.09-0.76 per cent respectively [7]. This coffee dehuller pre-extension demonstration and evaluation activity was therefore conducted in Diga and Sibu Sire districts with the objectives to 1) Create awareness among farmers on coffee dehuller 2) Evaluate the profitability of the machine under farmers' condition and 3) Assess feedback that worthy considering in improving the dehuller to the highest level of performance or effectiveness.

2. Material and Method

2.1. Description of the Pre-Extension Demonstration Area

2.1.1. Diga District

Diga is one of districts in the Oromia region of Ethiopia. Part of East Wollega zone, Diga is bordered on the east by Guto Gida, on south by Leka Dulacha, on the north by Sasiga, and on the west by Didesa river which separates it from west Wollega zone. The district is divided into two agro-ecological zones, locally called Gammojji, or lowland (tropic), which comprises 58% of the total area and has an altitude ranging between 1,000 and 1500 meters (4,921 and 8,543 ft) above sea level, and badda-dare, or midland (moist subtropical), which comprises 42% and has an altitude between 1,500 and 2500 meters (3,300 and 4,900 ft) above sea level. The badda dare agro-ecological zone is much cooler and receives more rainfall than the Gammojji. The district topography includes plateau, hilly and excessively steep slopes. It has low rainfall variability with 12.1% coefficient of variation, and receive most rainfall during long rainy season (June to September) [14].

The cultivated area covers 40.8% of the woreda (of which 32.7% of the total area is planted in annual crops), while 36.1% is pasture, 1.3% forest, 9% shrubland, 8.8% degraded on non-arable land, 2% is covered by bodies of water, and all other categories of land makes up the remaining 2% [16]. Major crops (cereal and pulse) in order of total production includes: maize, sorghum, finger millet, faba bean, haricot bean and soya bean [18]. Diga is also reported to have agro-ecological suitability for the production of some cash crops like coffee, sesame, and groundnut. Animal husbandry is also an important economic activity in Diga and include cattle, small-ruminant apiculture and poultry. Income from crop production and animal product is supplemented by pity trade and handicraft.

2.1.2. Sibu Sire

Sibu sire is located in East Wollega zone of Oromia national

regional state wester Ethiopia. It shares bounders with Guto Gida and Gudaya Bila to the north, Gobu Sayo to the east, Wayu Tuke to the west, and Bonaya Boshe and Wama Hagalo districts to the south. With Sire town as an administrative center Sibu Sire is located 273km west of Addis Ababa and 58 km away from Nekemte in the east direction. Geographically the district lies between 37°20'23'' to 45 °47'23''E and 27 °20'0'' to 45 °7'23'' N with the altitude ranges from 4567 to 8900 meter above sea level. The average annual rainfall of the study area was 1,500 mm distributed non-uniformly, with an average monthly mean maximum and minimum temperature of 27 °C and 10 °C, respectively.

Like many parts of Ethiopia, the district is an area where a mixed type of farming is practiced as a source of livelihood. Crop production is the most important for the community following by livestock husbandry and limited commerce. Cereals, pulses, coffee, and vegetable are the most commonly cultivated crop types in the area for both household consumption and market. The area has a huge potential for coffee production with more than 3 million hectares suitable for coffee production. But only less than 25% of the total potential lands are currently under coffee production. According to data received from [5], there are, 145,375 cattle, 50,152 sheep, 27,026 goats, 120, 000 poultry, 9088 horses, and others are the wealth of the district. The farmers of the district are also engaged in been keeping.

2.2. Description of the Machine Demonstrated



Figure 1. Pictorial view of the BAERC type coffee huller.

Table 1. specification of machine.

Parameter	Specification
Model	BAERC
Dimension (L*W*H)	120×69.5×117 mm

Parameter	Specification
Weight	45 kg
Prime mover	Engine
Engine model	KAMA
Engine output	9hp
Labour requirement	2
Construction material	Steel Metal
Dehulling capacity	240 kg/h

2.3. Site and Farmer Selection

This study focused on FSRP districts with particular emphasis on East Wollega zone of Oromia Region. In the zone FSRP operates in five districts. Considering coffee production potential of the area, two districts were purposively drawn from a list comprising districts benefiting FSRP intervention as provided by the zone administration office. From each district, two coffee-producing kebeles (sub-district) were picked based on the acreage under coffee cultivation, proximity and representativeness of the area. Once areas were identified, farmers who participated in the demonstration were selected based on prominent indicators, such as age, sex, technology use practices, literacy status, and others. Farmer selection was made in consultation with and inputs from office of agriculture and natural resources.

2.4. Coffee Dehuller Demonstration Approach

The demonstration work was conducted through inclusive and participatory approach between farmer, extension, and researcher. In the realm of the present research, three FRGs with membership of 15-20 coffee farmers (40% of whom were women) were organized and used. Prior to the start of the activity, these FRG members were trained and coached in numerous topics include the way to run the machine to dehull coffee, correct process to carry out minor repair of the huller, and basic safety checks. Immediate to training on farm demonstration and field days were covered and transmitted by Oromia Broadcasting Network Television to a wider community. Lastly focus discussions were performed to grasp participant's reaction on performance of demonstrated dehuller. Lastly focus group discussions were held with all participants to grasp their reaction on performance of demonstrated dehuller.

2.5. Data Types and Collection Methods

Participant interview, measurement, count and FGD were used to collect required data: Cost of operation, number of farmers attending training, demonstration/field days by gender and their reaction on technology demonstrated.

2.6. Data Analysis

Quantitative analytical methods were used to analyze the data. Simple statistics, such as frequency tables, and percentages were generated using Excel software.

2.6.1. Economic Feasibility Assessment

The cost of dehulling was calculated by considering the fixed and variable costs. Fixed costs include depreciation, interest, and shelter. Operating costs on the other hand, include repairs and maintenance, fuel, and Labor wage. Total cost of the machine is the sum of its total fixed costs and total variable costs.

2.6.2. Depreciation and Interest

Depreciation on mechanized thresher was calculated using the straight-line method according to Hunt (1983) using Equation (1) whilst the interest on machine ownership was calculated using Equation (2).

$$D = \frac{C-S}{L \times H} \quad (1)$$

$$I = \frac{C+S}{2} \times \frac{i}{H} \quad (2)$$

Where,

D = Depreciation per hour;

C = Initial cost of implement, Br;

S = Salvage value @ 10% of C, Br;

L = Working life of machine in years; and H = Number of working hours per year.

I = Interest per hour; and i = 10% per year

2.6.3. Housing Cost

The housing or shelter cost of the machinery may be defined as the cost required building the shelter or room to store the machinery or equipment. This cost is generally 1 per cent of the initial cost or capital cost of the machine as per the IS 9164: 1979.

2.6.4. Repair and Maintenance Cost

Most commonly this cost is taken as 5 to 10 per cent of the total capital cost of the machinery per year. (IS 9164: 1979).

Fuel consumption was measured by filling the engine fuel tank completely at the start and finish of each harvesting period and recording the quantity of fuel added.

3. Result and Discussion

3.1. Awareness Creation

3.1.1. Training

Table 1 presents stakeholders participated in the training across districts. Over the course of three days, 45 coffee farmers, including 10 women were trained on topics ranged from theoretical presentation to practical session. A team of researchers from engineering and extension explained farmers the right way to use the dehuller, how to carry out repair and maintenance, and avoid accident may cause during operation. 15 coffee experts and development agents also took part in the training for acquisition of awareness.

Table 2. Detail visualization of training participants.

District	Participants	Male	Female	Total
Sibu Sire	Farmers	13	2	15
	DAs	2	1	3
	Experts	3	1	4
	Total	18	4	22
Digga	Farmers	22	8	30
	DAs	3	1	4
	Experts	4	0	4
	Total	29	9	38



a



b

Figure 2. Training given at (a) Sibusire and (b) Diga districts.

3.1.2. Field Day Conducted

Farmers' field days were carried out in three villages of Sibusire and Diga districts to further enhance awareness of

coffee dehusser among small scale producers. As indicated in [Table 3](#), the attendant list of the event is 92 farmers 15 extension workers and 17 other stakeholders (official and media men).



Figure 3. Showcasing of the technology on field days.

Table 3. Stakeholders attended field days at the targeted areas.

Location	Participants	Male	Female	Total
Falamo Yubdo	Farmers	24	9	33
	Expert and DAs	5	2	7
	Other stakeholders (official, media men)	4	2	6
	Total	33	13	46
Gamachis	Farmers	38	21	59
	Experts and DAs	7	1	8
	Other stakeholders (officials)	7	4	11
	Total	52	26	78

3.2. A Comparison of Traditional and Machine-Assisted Coffee Dehulling Methods

The study compared the operational cost and labor requirements of the technology demonstrated with traditional dehulling method entails mortar and pestle.

The cost of operation and cost required to dehull coffee cherry by the powered dehuller was worked out. The detailed calculation is presented in the Table 4. The fixed cost, variable cost and total cost of the operation by the machine was found to be Br. 50.31, 122.75 and 173.06 per hour respectively. It was observed that the cost required to handle the one ton of

crop will be Br 721 with BAERC coffee dehuller. Similarly, the detailed calculation of the cost of operation by traditional method is given in Table 4. It was also calculated that Br 3150 will be required if traditional dehulling was used to dehull the one ton of coffee bean,

It was found that the net cost savings to farmers by switching from woody mortar and pestle to powered dehuller is birr 24294 (Table 5). Cost savings by dehuller usage leads to improved profitability in coffee cultivation. Additionally, it was observed that operation with the mechanical dehuller i.e., BAERC dehuller need only 4.17 man-hours per ton, a substantial decrease from the 40 man-hours required for manual coffee processing, representing an 89.58% reduction in dehulling time per 10 quintals.

Table 4. Cost of operation of different coffee dehuller methods.

Particulars	Developed Coffee huller	Traditional method (mortar and pestle)
Capital cost of machine (C), Br.	60800.00	-
Useful life of machine, year	6	-
Annual working hour, h	200	-
Salvage value (10% of C)	6080.00	-
Fixed cost		
Depreciation, Br. h ⁻¹	45.6	-
Interest, Br. h ⁻¹	1.67	-
Housing, Br. h ⁻¹	3.04	-
Total fixed cost, Br. h ⁻¹	50.31	-
Variable cost		
Fuel charges, Br. l ⁻¹	103.00	-
Fuel consumption, l h ⁻¹	0.28	-
Fuel cost, Br. h ⁻¹	28.80	-

Particulars	Developed Coffee huller	Traditional method (mortar and pestle)
Repair and maintenance cost, Br. h ⁻¹	15.2	-
Labour required,	2	2
Labour cost, Br. Day ⁻¹	315.00	315.00
Working hour, h day ⁻¹	8	8
Labour wages, Br. h ⁻¹	78.75	78.75
Total variable cost, Br. h ⁻¹	122.75	78.75
Total cost of operation, Br. h ⁻¹	173.06	78.75
Output capacity, kg h ⁻¹	240	25
Total cost of operation, Br. t ⁻¹	721	3150

Table 5. Cost comparison of different dehulling methods used for dry coffee bean.

S. N. Method	Threshing capacity, Kg h ⁻¹	Total cost of operation, Br.h ⁻¹	Total cost of operation, Br. kg ⁻¹	Per cent saving in cost over the traditional method
1. Traditional method	25	78.75	3.15	0.00
2. Power dehuller	240	173.06	0.72	77.14

3.3. Farmers' Perception on the Technology Attributes

Participants perception on both manual and BAERC type coffee dehuller Was depicted in Table 6. Regarding the usage of mechanized huller, the participants opined that it is portable, durable, cost effective, increase work efficiency and save time. Majority of the participants (94%) were neutral for the state-

ment that it is comfortable and convenient to use. This probably because they need time to get acquainted with the use of tool. But only with regard to availability of mechanized coffee dehuller their opinion was either neutral (87%) or disagree (37%).

Further, all the participants agreed that mortar and pestle is portable, durable, easily available and cost-effective tool. Meager percentage of the them (6%) were neutral and agree for the statement that it saves time & labor and reduces drudgery.

Table 1. Acceptability of the different coffee duller by field day participants (N=124).

Particulars	Coffee dehulling tools					
	BAERC model dehuller			Mortar and pestle		
	Agree	Neutral	Disagree	Agree	Neutral	Disagree
Comfortable & convenient to use	8 (6)	116 (94)	-	118 (95%)	6 (5)	-
Increases work efficiency and saves time	124 (100)		-	-		124(100)
Portable	124 (100)	-	-	124 (100%)	-	-
Durable	124 (100)	-	-	124 (100%)	-	-
Easy availability	-	87(70)	37(30)	124 (100%)	-	-
Cost effective	124 (100)	-	-	124(100%)		-

Particulars	Coffee dehulling tools					
	BAERC model dehuller			Mortar and pestle		
	Agree	Neutral	Disagree	Agree	Neutral	Disagree
Acceptability of the tool	124(100)	-	-	35 (28%)	89 (72)	-

Figures in the parentheses indicate percentage

4. Conclusion and Recommendation

The demonstration helped raise demand and awareness for the machine and enabled involved farmers and relevant experts to select the most proper dehulling option for their purpose. Claims of satisfactory machine performance has been reported. the data revealed that total cost of operation for coffee dehulling by BAERC coffee dehuller were found 77% cheaper than the traditional method of dehulling done by woody pestle and mortar but the initial cost of the machine was not at par with the mortar and pestle. The saving in time also 89.58 in percent. Hence from the above result it can be concluded that the demonstrated dehuller requires less labor and time, and also it is economical to the farmers. Therefore, the technology can go for mass popularization and multiplication to reach more smallholder coffee producers and multiple stakeholders in the future.

Abbreviations

BAERC	Bako Agricultural Engineering Center
Br	Birr
DA	Development Agent
FGD	Focus Group Discussion
FR	Farmer Research Group
FSRP	Food System Resilience Program
GDP	Gross Domestic Product
IS	International Standard
MT	Metric Tone
L*W*H	Length *Weight*Height

Author Contributions

Girma Ajama: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft

Conflicts of Interest

The author declares no conflicts of interest.

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