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ECONOMIC ANALYSIS OF THRESHING AND SHELLING MACHINE SERVICE PROVISION TO REDUCE POST-HARVEST LOSS IN ETHIOPIA

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ABSTRACT

The Sasakawa Africa Association (SAA) has been addressing the neglected post-harvest sector in Ethiopia through promoting improved storage facilities and introducing handheld and motorized crop shelling and threshing machines. However, post-harvest technologies are poorly adopted by the farmers although the traditional threshing methods often result in high grain losses and low-quality produces due to low awareness of the farmers and service providers on the benefits of the technologies. This study, therefore, was conducted in May 2020 to determine the socio-economic benefits of the threshing/shelling machine so as to inform the service providers on how to improve the adoption of the machine. A total of eight youth group service providers in four *woredas* of Oromia and Amhara regions in Ethiopia were selected for the study. In a unimodal rainfall production region, the Bako model maize sheller and the dehusker machines were assessed, whereas in a bimodal production region the multi-crop thresher was evaluated. Primary data were sourced through Focus Group Discussions (FGD) and Key Informant Interviews (KII) and secondary data were extracted through document review. Discounted economic parameters such as Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) were used for determining the profitability of the businesses. The result of the actual cashflow analysis in the unimodal area showed that the multi-crop thresher generated a negative NPV (USD -970)[1] with IRR value of -6% and a BCR value of 0.87. On the contrary, in the bimodal area, the NPV was found to be positive (USD 1917.3) with a BCR of 1.21 and IRR value 36%. Congruently, the Bako model maize sheller machine resulted in NPV of USD 8227.5, BCR value of 3.51 with IRR value of 133%. On the other hand, the dehusker machine generated NPV of USD 2247.5 with a BCR of 1.45, and IRR of 24%. The partial budget analysis of the farmers revealed that the threshing machine reduced the threshing costs by USD158.2 (51.9%) per hectare of land compared to the traditional threshing method. On the basis of the minimum food energy requirement, in the two districts alone, the maize grain that was lost through traditional shelling would have fed 3,939 individuals or 788 households, whereas for teff crop, the loss would have fed 6,163 adults or 1233 households throughout the year. Based on the findings, the authors recommend to scale-up the introduction of the machines in the bimodal production areas where two harvesting seasons exist and increase the service charge and working hours- in the unimodal area to improve entrepreneurs' profit and adoption of the machines.

Key words: post-harvest loss, shelling, threshing, dehusking, economic analysis, food security

[1] One USD is equal to 32.8 birr

INTRODUCTION

Due to inefficient management practices that allow crops to be contaminated by microorganisms, chemicals, excessive moisture, temperature extremes, spillage, mechanical damage, ineffective storage and so on, a significant amount of food is lost during post-production processes such as harvesting, drying, storage, processing, marketing, transporting and consumption. While continuing to produce more food in an innovative and sustainable manner, saving more of the food that has already been produced is an important strategy for unleashing agriculture's full potential to meet the anticipated higher global food and associated demand. Reduced food loss allows feeding of more people while saving money, improving local food security and reducing pressure on natural resources. Post-harvest loss reduction complements efforts to enhance food security through improved farm-level productivity, thus tending to benefit producers and more specifically, the rural poor. While the cost of loss reduction needs to be evaluated, it is likely that promoting food security through post-harvest reduction can be more cost effective and environmentally sustainable than a corresponding increase in production, especially in the current era of high food prices [1].

In Ethiopia, inefficient management practices account for a large portion of post-harvest loss. Farmers, for example, use prolonged standing field drying, manual/sickle harvesting, manure-smeared ground for threshing and grain separation by winnowing with a pitchfork or shovel, packing animals or humans for transporting, cribs or underground pits for storing, and other inefficient post-harvest loss reduction practices. Research conducted by World Food Program (WFP) between 2012 and 2014 shows that in both west and east Africa the average post-harvest losses go above 40 percent [2]. Although accurate post-harvest loss data is lacking in Ethiopia, use of the mechanical thresher significantly reduces crop loss as compared to traditional method. It was estimated that traditional post-harvest handling causes an average loss of 15-20% of produces, with incidents reaching up to 50%. The significant loss in traditional methods is due to scattered crops, adulteration with cow dung, loss of grains with the straw and through animal feed while threshing [3].

In response to this, Sasakawa Africa Association (SAA) has been working on post-harvest management since 1995, introducing small-scale crop threshing and shelling machines and other storage technologies, among other things. Given the inability of small-scale farmers to purchase these machines individually and in light of the growing rural unemployed youth population, SAA developed a private machine service provision model to disseminate the technologies while also creating employment opportunities for rural youths. In this model, a single person or a group of like-minded young people own machines and charge farmers for threshing and shelling services while also providing post-harvest extension services to farmers. Threshing and shelling service providers are linked to maintenance service providers, machine fabricators, spare part suppliers and financial service providers to ensure the model's sustainability.

Over the years, a number of youth groups have been organized, trained and machines have been made available for them to engage in threshing and shelling service provision businesses. However, the benefits of the machine threshing and shelling business have not been thoroughly investigated for both entrepreneurs and smallholder farmers. Therefore, this study was carried out to assess the economic feasibility of the thresher and sheller machine service provision businesses, the socio-economic impact of the service on the farming communities and the barriers to service providers as well as smallholder farmers.

MATERIALS AND METHODS

The study was carried out in eight farmer associations, two administrative regions and four districts of Ethiopia: three districts of the Amhara region (Bure, Womberma and Estie) and one district of the Oromia region (Shashemene) with two farmer associations in each of the districts.

Sample population

A total of eight Focus Group Discussions (FGDs) with groups of farmers consisted of 10 to 12 members each in four *woredas*, eight *kebeles*: Womberma-Heret, Womberma-Markuma, Bure-Ser Tekez, Bure-Zalema, Este-Zigora Gebriel, Shashemene-Awash Denku, Shashemene-Umbure, and Shashemene-Oune Chefo were conducted. In addition, eight Key Informant Interviews (KIIs) were carried out with Development Agents to extract the relevant data in relation to the socio-economic benefits of conventional and machine threshing/shelling practices. Overall, 104 (with 27 female) respondents including service providers, FGD participants, and Key Informant Interview respondents were engaged in providing the required data based on the data collection instruments designed for it. A total of eight youth group service providers were selected purposively taking into account the area of operation as well as the type of thresher and sheller machine technology ownership. Four maize sheller machine service providers (two owning big and the other two owning small sheller machines) were chosen in the unimodal rainfall areas of Amhara, while four multi-crop thresher machine service providers were chosen both from the unimodal and bimodal rainfall areas of Amhara and Oromia regions.

Data collection tool

Primary data were collated through structured and semi-structured questionnaires in order to extract both qualitative and quantitative data. Secondary data were gathered from service providers' financial recording book (cash inflow and outflow) and district annual reporting documents to extract the share of land allocated to each crop, their production and productivity, and input supply related information. A review of previous studies on related topics was also conducted. Document review was employed to capture the actual cash flow of the service providers and in-depth interview was conducted with them to extract qualitative data explanatory to the cash flow records.

Data analysis

The data were analyzed using Excel spreadsheet and Pivot Table Visualization tool. For the quantitative measurement parameters, descriptive statistical methods such as percentage, mean, minimum and maximum statistical parameters were used to assess the scale of the business operating level. Discounted economic parameters such as Net

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Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) were also used to examine the profitability and feasibility of the businesses. It is evidenced that a certain amount of money today is worth more than the same amount received in future [4]. The payback period was estimated to appraise the time in which the initial outlay of the investment is recovered through the cash inflows generated by the investment. Tables and graphical presentations were used to visualize various statistical results.

Net Present Value (NPV) is a capital budget technique used to determine the present value of discounted future payments at an appropriate rate [5]. This was used to calculate the difference between the present value of net cash inflows and outflows, using the following formula:

$$NPV = -CF_0 + \frac{NCF_{t1}}{(1+i)^{t1}} + \frac{NCF_{t2}}{(1+i)^{t2}} + \cdots + \frac{NCF_{tn}}{(1+i)^{tn}} \quad \ldots\ldots (1)$$

$$NPV = -CF_0 + \sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t} \quad \ldots\ldots (2)$$

Or, this can be written in the form of:

$$\mathbf{NPV} = \sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t} - CF_0 \quad \ldots\ldots (3)$$

Where: NPV=net present value; NFC_t= net cash flow during the period t; CF_0 = initial investment/cost; t = the period in year; i=discount rate; n=duration of the project.

According to Julian and Seavert [6], the NPV rule should be used to make decisions on the investment. When NPV < 0, investment should be rejected, when NPV > 0, investment should be accepted. The NPV equation considers all the costs and desired rates of return. Therefore, investing in something that has a net present value greater than zero logically increases a company's earnings since it achieves the expected financial objectives.

Benefit Cost Ratio (BCR) is the ratio of project benefits versus project costs. It involves summing the total discounted benefits for a project over its entire duration/life span and dividing it over the total discounted costs of the project [7].

$$\mathbf{B/C} = \frac{\sum_{j=1}^{n} Rj\,(1+i)^j}{\sum_{j=1}^{n} Cj\,(1+i)^j}$$

Where: B/C=cost benefit ratio; Rj = revenues during the period j; Cj = costs during the period j; i=discount rate

Internal Rate of Return (IRR) was computed to determine the rate at which the investment breaks even [8], which is calculated as:

$$NPV \sum_{j=1}^{n} \frac{NCF_t}{(1+i)^t} - C_0 = 0 \qquad i = IRR$$

This can be expressed as:

$$\textbf{NPV}=\sum_{j=1}^{n}\frac{NCF_t}{(1+\text{IRR})^{t}}-C_0=0$$

Where: IRR=internal rate of return; NCF_t= net cash flow during the period t; C_0 = initial investment/cost in year 0; i = discount rate in decimals; t= year in period t n=total duration of the project in years.

The daily food energy requirement of an adult person was used for estimating the number of people to be food-secure if the post-harvest loss reduced due to the promoting machine. The daily food energy requirement of an adult person was estimated by successive FAO/WHO Expert Committees. The estimation was made based on two reports. The first is that of a Joint FAO/WHO Ad Hoc Expert Committee on Energy and Protein Requirements, which met in 1971 (referred to as the 1971 Committee) and which reported in 1973 (referred to as the 1973 report). The second is the report of a joint FAO/WHO informal gathering of experts, which met and reported in 1975 (referred to as the 1975 report) [9].

The average daily food energy requirement of men = 3000 Kcal…………………….1

The daily food energy requirement of women = 2200 Kcal……………………..…2

The cumulative average daily food energy requirement of men and women
= 2600 Kcal ……………………………………………………………………...3 [10].

RESULTS AND DISCUSSION

The current state of machine service providers and machine fabricators

Sasakawa Africa Association (SAA) was the first to introduce the multi-crop thresher machine in Shashemene area over a decade ago. The study revealed that the Shashemene town has four machine fabricators, resulting in 300 multi-crop thresher machine service providers in the area. As a result, nearly all of the smallholder farmers in the Shashemene area have adopted threshing/shelling machines. According to the FGD discussants and Key Informant Interviewees, the availability of private service providers combined with a high demand of the service from the farmers' side because of its product quality, saving time and money, as well as proximity of machine fabricators and maintenance service providers in a nearby town, were the primary driving factors behind the machine's high adoption rate in the area. Furthermore, the bimodal rainfall pattern allows farmers to use double cropping practices and hence, the threshing service business could run in most of the months over the year which would help to easily adopt the technologies.

The Amhara region, on the other hand, had no threshing/shelling machine fabricators. As a result, the proportion of farmers using threshing/shelling machines appeared to be very low in the districts of Womberma (40%) and Bure (19.8%). The threshing machine helped to reduce the grain losses, improved grain quality and reduced threshing costs for the farmers. In addition, farmers were able to prepare themselves for the second production season earlier than it would have been possible otherwise.

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Initial investment and operating costs of the service providers

In the Womberma-Heret and Bure-Zalima study areas where maize dehusker-sheller machine was in use, the service providers incurred an initial investment cost of Birr 190,000 for the machine alone. Whereas, for the Bako-model maize sheller machines the average initial investment cost was Birr 64,500.

On the other hand, the average actual operating cost of the maize dehusker-sheller machine was found to be Birr 23,150, with costs ranging from Birr 16,720 to 29,580 depending on location. However, the entrepreneurs could not work for the entire threshing season due to late acquisition of the machines coupled with too many non-working religious holidays. Hence, this cost does not reflect the potential operating costs of the business. With the potential working capacity, however, the average operating cost would have risen to Birr 39,137. Fuel expense was found to be the major cost item of all operating costs, followed by maintenance and oil and lubricants. The actual average operating cost of the Bako-model sheller machine was calculated to be Birr 26,984, which would rise to Birr 32,679.4 with the potential working capacity. Similarly, the highest share of the total operating costs of the dehusker-sheller machine was for fuel expenses, followed by remuneration and maintenance costs, Figure 2.

Source: Computed from the financial recording book of the SPs

Figure 1: Actual and potential operating costs-Bako model

Source: Computed from the financial recording book of the SPs

Figure 2: Actual and potential operating costs- Dehusker

Likewise, the initial investment cost and operating costs of the multi-crop thresher machine was calculated. Accordingly, the average initial investment cost for the multi-crop thresher machine was found to be Birr 80, 451. The investment cost varied from entrepreneur to entrepreneur due to differences in cost of machine and other accessories.

The actual average annual operating cost incurred by the multi-crop thresher machine service providers was Birr 62,458. However, with full working capacity for the entire season, the average operating cost would be Birr 90,128.6. The major share of the total operating costs goes to fuel expenses followed by operator remuneration, transportation and oil and lubricant costs, Figure 3.

Source: Computed from the financial recording book of the service providers

Figure 3: Actual and potential operating costs- multi-crop thresher

Depreciation and cost of capital

Depreciation costs for fixed assets and the cost of capital were factored in for calculating the total annual cost of the business, and a 10% interest rate was used for calculating the cost of capital as most of the Financial Institutions used a 10% interest for loanable funds. Moreover, a straight-line depreciation schedule was applied to calculate the depreciation cost of fixed assets assuming that the economic life year of the machine is 5 years. This is because, most of the thresher machines had a lower likelihood of providing service beyond five years or requires significant replacement costs. Therefore, the salvage value of the machine after five years was assumed to be the same as its accounting value, which is 1 birr. Based on these assumptions, the average annual depreciation cost of the Dehusker-sheller and Bako Model Sheller machine was calculated to be 38,000 Birr and 12,900 Birr, respectively (Figure 4). The average cost of capital was found to be Birr 10,443 for the Dehusker-sheller and Birr 9879.8 for the Bako Model Sheller Machine.

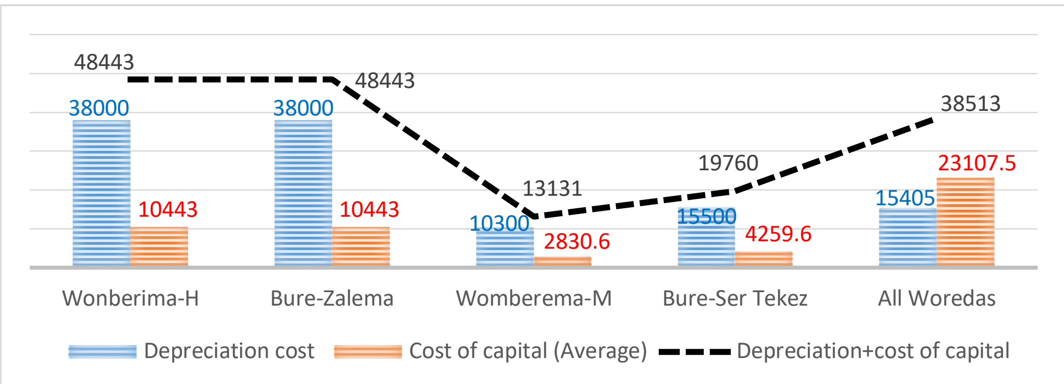

Figure 4: Depreciation and cost of capital for maize sheller in different areas (Birr)

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Similarly, the multi-crop thresher machine's annual depreciation cost was found to be 8,040 Birr, on the average, which is ranged from 6,498 to 10,568 Birr due to initial investment cost differences. The average cost of capital for the investment fund was 20,100.3 Birr, with service providers in Awash Denku, Oune Chefo and Umbure incurring the lowest and highest costs of capital, respectively, as shown in Figure 5.

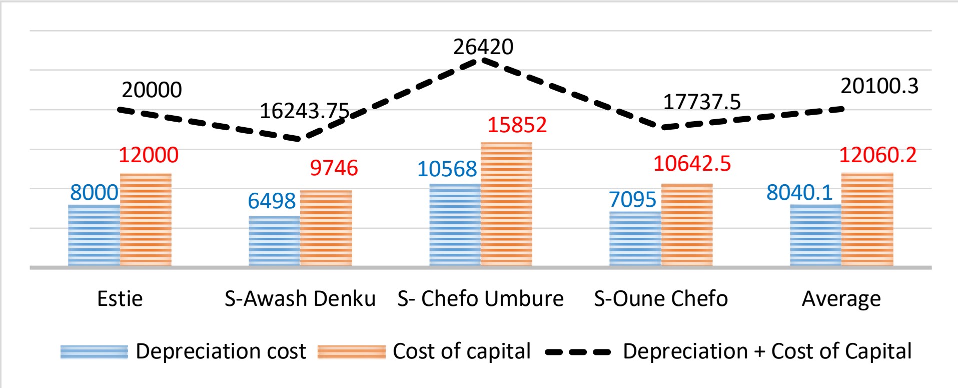

Figure 5: Depreciation and cost of capital for multi-crop thresher in different areas (Birr)

Discounted rate of economic analysis

Bako model maize sheller machine According to the actual cashflow cost-benefit analysis, the Bako-model maize sheller machine generated a gross revenue of Birr 528,400 over its five-year economic lifetime, assuming all other costs (service fees and other operational costs) remained constant. The service providers' total cost, on the other hand, was Birr 150,670. Variable costs accounted for 45.4 % of the total cost, whereas the investment cost had a share of 42.8%. Overall, the Present Value (PV) of the service providers' cost was found to be Birr 179649.6 and that of the PV of the revenue was Birr 400,610.35.

Using the various discounted profitability measures, the business was found to be highly profitable on the basis of the actual cash flow analysis. The NPV of the business was found to be Birr 269861.9, and the BCR 3.51, which is greater than the standard threshold of one, indicating that for every one-Birr invested in the business, 3.51Birr is earned, including the one-Birr investment. Furthermore, the IRR was found 133 %, with a payback period of 1 year.

Since the actual cash flow did not reflect the true profitability analysis of the business due to untapped seasonal working time, a profitability analysis was done using the projected potential working capacity cash flow data. Accordingly, the NPV of the enterprises for the overall operations was Birr 497337.9, with a BCR 3.69. In addition, the IRR was calculated to be 227%, which is significantly higher than the cost of capital. Based on this outcome, every one Birr investment generated a net profit of Birr 2.69, with investment payback period of one year.

Dehusker sheller machine
On the basis of the actual cash flow analysis, the total gross revenue of the Dehusker sheller service provision business was calculated to be Birr 519,375, which is equivalent to a calculated PV of Birr 393767.9 using 10% discount rate. As Table 2 depicts, based on the actual cashflow analysis, the economic benefit of the business over the machine's five-year economic lifetime was Birr 161,409. The NPV of the businesses was found positive with a monetary value of Birr 73720.2. The BCR was calculated to be 1.45, which is greater than the profitability threshold of one. The IRR was found to be 24%, and the payback period was 3.3 years.

When it comes to the potential working capacity, the gross revenue increased to Birr 819,375 during the machine's economic lifetime, with a total estimated cost of Birr 437,900.9. The PV of the gross revenue was Birr 621,215.2, and that of the total cost was Birr 453720.2. The NPV of the business was found to be positive, with a monetary value of Birr 240,564.1. The BCR was 1.87, which is significantly higher than the profitability threshold of 1. The IRR of the business was 51%, which is much higher than the current interest rate of the financial loan service providers, and the payback period was found to be 2.5 years.

Multi-crop thresher machine
Comparison was made between the profitability of the business in the unimodal and bimodal rainfall pattern areas. According to the findings, the threshing service in the unimodal crop production area was not found to be a profitable investment in various profitability measurement parameters. The NPV of the business was negative, with a monetary value of Birr 31,826.5 (Table 3). This equates to a loss of Birr 31,826.5 over the machine's economic lifetime. The BCR was 0.87, which is less than the breakeven point. As the IRR is negative (-6%), the initial investment will never be repaid back within the machine's economic lifetime unless the current business modality is changed. The limited working days due to religious holidays, frequent machine breakage on the threshing axle combined with lack of maintenance service providers in a nearby town were mentioned by the service providers as business challenges.

The NPV, on the other hand, was found positive in the bimodal crop production area, with a cumulative value of Birr 62,886.1. The IRR was found to be 36% with a BCR value of 1.21. This means, if the investment was made with own money, the company profited at a rate of 21% of the investment. This implies that entrepreneurs would never go bankrupt if they could obtain an investment loan with an interest rate of up to 21%. With this business modality, the initial investment will be paid back within 2.4 years. A similar study that was done by SAA in 2015 in this specific area showed that the NPV of the business was positive with a payback period of 1.5 years [11].

Likewise, the business was found highly profitable in its potential working capacity in both a unimodal and bimodal production areas. In the unimodal production areas, the NPV was found positive with a monetary value of 56472.3, BCR value 1.77. Concurrently, in the bimodal areas it had Birr 215,833NPV with a BCR value of 1.56. In this case, the multi-crop thresher machine in the bi-modal crop production area was found more profitable than the unimodal crop production area. Lack of self-powered engine with the machine to transport itself exposed the service providers to high cost of transportation service charge. Access to fuel from the regular fuel station was also impossible to the service providers which urged them to access the fuel with extra expenses.

The IRR also resulted in a greater profit in the bimodal crop production area, which was found to be 34% and 92% of the total investment in the unimodal and bimodal operating areas, respectively. The payback period of the initial investment was 2.3 and 1.8 years in the unimodal and bimodal crop production areas, respectively (Table 4). A similar study on multi-crop thresher machine rental business in Asella District of Oromia region showed that the internal rate of return for the machine was 44% with a payback period of 2 years [12].

ECONOMIC ANALYSIS OF FARMERS' CROP THRESHING BUDGETS

A comparison of traditional and machine-assisted maize shelling methods

The conventional maize shelling cost was Birr 7,741.1 per hectare, on the average, whereas, with the sheller machine farmers spent Birr 5,291 per hectare. Human labor accounted for 71.5 % of the total cost, while food and drinks accounted for 16 %, and animal labor 12.5 % in the conventional method. Similarly, labor costs continued to have significant share of the maize shelling cost with the machine, which accounted for 50.2 %. This was due to the lack of dehusking accessories with the Bako-model maize sheller machine, which required a significant amount of manual labor to complete the task. The service charge of the machine accounted for 21.4 % of the total cost, respectively (Table 5).

According to the FGD discussants, the machine reduced losses/increased yield by 33.3 kg/ha such that the average yield would be 6450 kg/ha, while with the conventional method it would be 6483.3 kg/ha. This is because, unlike the traditional method, farmers use canvas to avoid crop loss when using the sheller machine and no grain is left with the cob. Moreover, the use of a machine reduced cost of threshing for the farmers by 2450 Birr/ha, or 31.7 % over the cost of conventional shelling method. The BCR of the conventional maize shelling was found to be 8.17, while the maize sheller machine was 12.48. This demonstrates that the machine increased the overall return on investment of maize production.

Similarly, the multi-crop thresher machine has also reduced threshing costs while increasing yield through reduction of losses (Table 6). The total cost of threshing teff by hand was Birr 7541.25 per hectare, whereas the cost was reduced to Birr 3,630 with the threshing machine. Human labor was discovered to be the largest share (49.6 %) of the total threshing cost of teff using the traditional threshing method. Likewise, labor costs accounted for 46.4 % with the thresher machine. This is because, the machine had no sieving accessories and winnowing was done with human labor. The machine service charge had a share of 35.5 %, while food and beverage costed 18%.

After having a thorough discussion, three of the FGD groups participants agreed that the threshing machine reduced the teff grain losses by at least 45 kg/ha over the conventional threshing methods. However, some of the discussants in one FGD group estimated the figure to 60 kg/ha of land. All of the discussants were in agreement that the thresher machine unlike the conventional threshing, uses canvas underneath to collect grains during threshing. This avoids losses of grain through animal feed, soil contamination and wind blowing during winnowing. With one of the group discussants, the issue of untimely rain which causes a huge loss of grain in the case of traditional threshing through shattering and water soaking of grain was raised due to its prolonged days of hipping and threshing process.

For availability and affordability of the thresher machine rental service, all of the FGD participants in eight groups were comfortable with the service charge imposed by the service providers. However, two of the FGD discussants in the unimodal production areas had disagreement on the availability of the service up on their demand. This is because, the number of thresher machines available in their localities were very limited to reach out to all the farmers. In addition to this, the FGD participants and KIIs in the unimodal production area raised the lack of maintenance service providers in a nearby town coupled with limited access to fuel for operating the machine curbed the ability of the service providers to make the machine accessible to the farmers on demand basis. On another note, three KIIs in Amhara region brought up the issue of too many religious holidays, which restricted the service providers to render the service as they wanted to do. The FGD participants, however, did not mention this issue as a challenge because of the religious taboo.

According to the partial budget analysis, the net benefit of using machine for teff threshing was far greater than the net benefit of using the traditional threshing method. The multi-crop thresher machine would assist farmers in increasing yields by lowering losses and threshing costs. The threshing machine reduced costs by 5201.25 Birr, or 51.9 % of the total threshing cost. The BCR of the conventional method was 6.19, while the BCR of the thresher machine was 14.73.

The impact of threshing and shelling machines on household income and food security

Addressing food security is high on Ethiopia's priority list for economic development. One of the reasons for the country's failure to achieve food security is the high level of post-harvest losses caused by inadequate post-harvest handling and storage facilities. The traditional animal trampling method is the most common method of threshing crops in Ethiopia, resulting in high loss and low-quality produce, putting Ethiopia's efforts to achieve food security at risk.

Following the findings of this study, estimation was made on how many households would be food secure if the current grain losses through traditional threshing/shelling method had been halted. Given that the average minimum daily food energy requirement of an adult person is (2600 Kcal) [10] and the food energy content of maize/corn is (4030Kcal/kg) and teff (4120 Kcal/kg) [10]. Accordingly, the volume of the grain loss was estimated for the number of people it would have fed. The volume of crop lost annually due to conventional maize shelling in the maize production belt area of Womberma and Bure Districts was 504.36 ton and 423.1 ton, respectively. Similarly, crop losses due to poor threshing management by farmers in the teff production areas of Estie and Shashemene Districts were projected to be 786 ton and 633.4 ton, respectively. Based on an adult's food energy requirement threshold, the lost maize and teff crops would have fed 3939 people or 788 households, and 6163 people or 1233 households, respectively, all year. The loss has a significant negative impact on the household's income in monetary terms. According to the analysis result of this study, in a single agricultural year, the value of maize and teff which was lost in the study areas amounts to Birr 10,201,821 and 22,954,196.25, respectively, at current market prices.

CONCLUSION

Based on the study's findings, the following conclusions are reached and recommendations are made for further improvement. All economic and financial feasibility parameters confirm that the threshing and shelling service provision business is highly profitable except teff threshing business in the unimodal area. Although the initial investment spikes high, the annual operating cost is relatively low. The thresher and sheller machines provide significant socioeconomic benefits to smallholder farmers by reducing grain losses, threshing costs, drudgery and time. In addition, compared to the traditional threshing method, the thresher/sheller machine meaningfully improves the quality of the produce. Despite the fact that the thresher/sheller machine provide significant benefits to both service providers and smallholder farmers, the adoption of the machine is very low with the exception of Shashemene area, where a double cropping is common. In the unimodal area where there is a single production season, the adoption rate of the machine is low as it allows the service providers to operate the business for a limited period of time. In addition, the low rate of machine adoption has been cited as a lack of maintenance service providers, spare part suppliers and machine fabricators in a nearby town. Due to the lack of dehusking accessories with the Bako-model maize sheller machine, it still requires a significant amount of human labor, for dehusking the cobs and winnowing the grain. The study shows that the threshing/shelling business is highly profitable with a huge potential of job creation in the rural areas. However, with the current mode of service delivery in the unimodal area of Estie District, the business bears no profit for the entrepreneurs.

As part of the recommendation, entrepreneurs in the unimodal production area need to fix a greater service charge and increase the total number of working hours over the year. There is also a need for the thresher/sheller machine service providers to diversify their businesses into other Agri-service provision such as tillage, chemical sprayer, harvester machine, and storage facility supply services to generate income in all year rounds. Researchers and machine fabricators should develop better quality machines to avoid frequent breakage, provide self-powered movable machines with sieving accessories. Capacity building trainings in areas such as machine operation and safety, business plan development, record keeping, financial management and customer handling is required to improve service providers' knowledge and skills. Efforts should also be made to provide credit services to youth service providers.

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Table 1: The actual and potential cash flow analysis of Bako model maize sheller machine (Birr)

Costs and Revenue		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Gross revenue	Actual	0	105680	105680	105680	105680	105680	528400
	Potential	0	185940	185940	185940	185940	185940	929700
Costs								
Investment Cost		64500						
Variable Costs	Actual		13688.9	13688.9	13688.9	13688.9	13688.9	68444.4
	Potential		33941.3	33941.3	33941.3	33941.3	33941.3	169707
Cost of capital	Actual		5979	4883	3672	2335	857	17726
	Potential		5979	4883	3672	2335	857	17726
Depreciation	Actual		12900	12900	12900	12900	12900	64500
	Potential		12900	12900	12900	12900	12900	64500
Total Costs	Actual		32567.9	31471.9	30260.9	28923.9	27445.9	150670.5
	Potential		52820.3	51724.3	50513.3	49176.3	47698.3	251932.5
Net profit	Actual		73112.1	74208.1	75419.1	76756.1	78234.1	377729.5
	Potential		133119.7	134215.7	135426.7	136763.7	138241.7	677767.5
Net Cashflows	Actual	-64500	86012.1	87108.1	88319.1	89656.1	91134.1	377729.5
	Potential	-64500	146019.7	147115.7	148326.7	149663.7	151141.7	677767.5
NPV (10%DR)	Actual	-64500	78192.8	71990.2	66355.4	61236.3	56587.1	269861.9
	Potential	-64500	132745.2	121583.2	111440.0	102222.3	93847.1	497337.9

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Table 2: The actual and potential cash flow analysis of the dehusker maize Sheller Machine

Costs and Revenue		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Gross revenue	*Actual*	*0*	*103875*	*103875*	*103875*	*103875*	*103875*	*519375*
	Potential	*0*	*163875*	*163875*	*163875*	*163875*	*163875*	*819375*
Costs								
Investment cost		*190000*						
Variable cost	*Actual*		*23150*	*23150*	*23150*	*23150*	*23150*	*115750*
	Potential		*39137*	*39137*	*39137*	*39137*	*39137*	*195685*
Cost of capital	*Actual*		*17612*	*14,384*	*10,817*	*6,878*	*2,525*	*52216*
	Potential		*17612*	*14,384*	*10,817*	*6,878*	*2,525*	*52216*
Depreciation cost	*Actual*		*38000*	*38000*	*38000*	*38000*	*38000*	*190000*
	Potential		*38000*	*38000*	*38000*	*38000*	*38000*	*190000*
Total Cost	*Actual*		*78762*	*75,534*	*71,967*	*68028*	*63675*	*357,966*
	Potential		*94749*	*91,521*	*87,954*	*84015*	*79662*	*437,901*
Net profit	*Actual*		*25113*	*28,341*	*31,908*	*35847*	*40200*	*161,409*
	Potential		*69126*	*72,354*	*75,921*	*79860*	*84213*	*381,474*
Net Cashflows	*Actual*	*-190000*	*63113*	*66,341*	*69908*	*73847*	*78200*	*161409*
	Potential	*-190000*	*107126*	*110,354*	*113921*	*117860*	*122213*	*381474*
NPV (10%DR)	*Actual*	*-190000*	*57375.5*	*54827.3*	*52522.9*	*50438.5*	*48556.0*	*73720.2*
	Potential	*-190000*	*97387.3*	*91201.7*	*85590.5*	*80500.0*	*75884.7*	*240564*

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Table 3: Actual cash flow cost-benefit analysis for Multi-crop Thresher rental business

Costs and Benefits		*Year 0*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Total*
Gross revenue	Unimodal		19950	19950	19950	19950	19950	99750
	Bimodal		125013.8	125014	125013.8	125014	125014	625068.8
Investment cost	Unimodal	80200						
	Bimodal	80535						
Variable cost	Unimodal		2480	2480	2480	2480	2480	12400
	Bimodal		82451	82451	82451	82451	82451	412253.2
Cost of capital	Unimodal		7,434	6,072	4,566	2,903	1,066	22041
	Bimodal		7,465	6,097	4,585	2,915	1,070	22132
Depreciation cost	Unimodal		16040	16040	16040	16040	16040	80200
	Bimodal		16107	16107	16107	16107	16107	80535
Total annual Cost	Unimodal		25,954	24,592	23,086	21,423	19,586	114,641
	Bimodal		106,023	104,655	103,143	101,473	99,628	514,922
Net profit	Unimodal		-6,004	-4,642	-3,136	-1473	364	-14,891
	Bimodal		18990.8	20358.8	21870.8	23,541	25,386	110,147
Net Cashflows	Unimodal	-80200	10,036	11,398	12,904	14567	16404	-14891
	Bimodal	-80535	35,098	36,466	37,978	39647.8	41492.8	110147
NPV (10%DR)	Unimodal	-80200	9123.6	9419.8	9695.0	9949.5	10185.6	-31826.5
	Bimodal	-80535	31907.1	30137.0	28533.3	27080.0	25763.8	62886.1

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Table 4: Potential working Capacity cash flow cost-benefit analysis for multi-crop thresher (Birr)

Costs and Benefits		*Year 0*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Total*
Gross revenue	Unimodal		46550	46550	46550	46550	46550	232750
	Bimodal		173039	173039	173039	173039	173039	865194
Investment cost	Unimodal	80200						
	Bimodal	80535						
Variable cost	Unimodal		5786.7	5787	5786.7	5786.7	5786.7	28933.3
	Bimodal		90129	90129	90129	90129	90129	450643
Cost of capital	Unimodal		7,434	6,072	4,566	2,903	1,066	22041
	Bimodal		7,465	6,097	4,585	2,915	1,070	22132
Depreciation cost	Unimodal		16040	16040	16040	16040	16040	80200
	Bimodal		16107	16107	16107	16107	16107	80535
Total annual Cost	Unimodal		29,261	27,899	26,393	24,730	22,893	131,176
	Bimodal		113701	112333	110821	109151	107306	553,312
Net profit	Unimodal		17,289	18,651	20,157	21,820	23,657	101,574
	Bimodal		59338	60706	62218	63888	65733	311,882
Net Cashflows	Unimodal	-80200	33,329	34,691	36,197	37860	39697	101574
	Bimodal	-80535	75,445	76,813	78,325	79995	81840	311882
NPV (10%DR)	Unimodal	-80200	30299	28670	27195.3	25858.9	24648.7	56,472
	Bimodal	-80535	68586.2	63482	58846.6	54637.5	50816.1	215,833

Table 5: Partial budget analysis for using maize sheller machine (Birr)

	Conventional	Machine
Gross revenue	70950	71316.3
Costs		
Machine rental cost	0	1133
Cost of human labor	5538.1	2658
Cost of Animal Labor	967	316.7
Cost of Food and Drink	1236	1183.4
Total cost that varies	7741.1	5291.1
Net benefit	63208.9	66025.2

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Table 6: Partial Budget Analysis for using teff thresher machine

	Conventional	*Machine*
Gross revenue	54250	55825
Costs		
Machine rental cost	0	1290
Cost of human labor	3741.25	1685
Cost of Animal Labor	1050	0
Cost of Food and Drink	2750	655
Total cost that varies	7541.25	3630
Net benefit	46708.75	53485

Table 7: Crop loss projection and its implication on food security in the study districts

	Womberema	*Bure*	*Estie*	*Shashemene*
Description	**Maize**	**Maize**	**Teff**	**Teff**
Area of land covered by the crop (ha)	15,146	12,705	17468.25	14,075
Maize loss (kg)	504361.8	423076.5		
Teff loss (kg)			786071.25	633375
Energy content of a crop (Kcal/kg)	4030	4030	4120	4120
Total food energy content of the crop lost (Kcal)	2032578054	1704998295	3238613550	2609505000
Annual food energy requirement of an adult (Kcal)	949000	949000	949000	949000
Number of adult persons to be food secured	2142	1797	3413	2750

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REFERENCES

1. **World Bank.** Missing Food: The Case of Post-harvest Grain Losses in Sub-Saharan Africa. *Washington, DC. © World Bank*. 2011; accessed September 2020 at https://openknowledge.worldbank.org/handle/10986/2824

2. **Costa SJ** Taking it to scale: Post-Harvest Loss Eradication in Uganda 2014 – 2015. Global Post-Harvest Knowledge and Operations Centre, Kampala, Uganda. Project Implementation Report. 2015.

3. **Admassu S, Bedaso T, Wondwossen T, Oumer T, Aberash T, Mesfin K and C Fikadu** Dissemination, Adoption and Impacts of Multi-Crop Threshers in Ethiopia: Experience of Sasakawa Global 2000. Technical report. 2014; accessed at https://www.researchgate.net/publication/291426310

4. **Frey TL** Time Value of Money and Investment Analysis: Explanation with Application to Agriculture. Dept. of Agri. Econ. University of Illinois, AET. 1976; 15-76.

5. **Gitman LJ** Principles of Managerial Finance 12th Edition. Pearson Addison Wesley. 2010.

6. **James W Julian and Clark F Seavert** AgProfit: a net present value and cashflow based decision aid for agriculture producers; Agricultural Finance Review. Emerald Group Publishing, 2011; **71 (3)**: 366-378.7.

7. **Shively G and M Galopin** An Overview of Benefit-Cost analysis. Department of Agricultural Economics. Purdue University.2012.

8. **Eltahir Y** Internal Rate of Return: A suggested Alternative Formula and its Macroeconomic Implications. *J Am Sci*. 2014; **10 (11)**: 216-221. ISSN: 1545-1003.

9. **WHO.** Protein and energy requirements: A joint FAO/WHO Memorandum. Bulletin of the World Health Organization. 1979; **57 (1)**: 65-79.

10. **FAO. Food and Nutrition Paper 77.** Food energy - methods of analysis and conversion factors: Report of a Technical Workshop, Rome. 2002.

11. **Sasakawa Global 2000 (SG2000).** Dissemination, Adoption and Impacts of Multi-Crop Threshers in Ethiopia. Experiences of Sasakawa Global 2000, Working Paper, No. 04, 2015.

12. **Gebiso TC** Economic Evaluation of Asella Model-III Multi-crop Thresher, *International Journal of Agricultural Economics*. 2018; **3(3)**: 45-52.