Economic Affairs, Vol. **69**(01), pp. 509-516, March 2024
DOI: 10.46852/0424-2513.2.2024.13

AESSRA

RESEARCH PAPER

Economic Analysis and Feasibility of Tractor Operated Pulse Crop Harvester

S. Rahaman[1*], B. Hari Babu[2], A. Ashok Kumar[3], K. Madhusudhana Reddy[4] and V. Srinivasa Rao[5]

[1]Department of Agricultural Engineering, Aditya University, Surampalem, Andhra Pradesh, India
[2]Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, Madakasira, Andhra Pradesh, India
[3]AICRP on FIM Scheme, Dr. NTR College of Agricultural Engineering, Bapatla, India
[4]Department of Agricultural Engineering, Regional Agricultural Research Station, Tirupati, India
[5]Department of Statistics and Computer Application, Agricultural College, Bapatla, India

[*]Corresponding author: caerahaman62@gmail.com (**ORCID ID:** 0000-0001-9047-942X)

Received: 21-12-2023 **Revised:** 26-02-2024 **Accepted:** 04-03-2024

ABSTRACT

Traditional harvesting is a labor-intensive and expensive procedure; farmers often spend 25 to 30 percent of crop production costs on harvesting. Harvesting at right time is most important factor, as delay of harvesting operation results in significant grain loss due to shattering their by reducing yield of a crop. The feasibility and adoptability of developed pulse crop harvester was evaluated by following constrains such as benefit cost ratio, breakeven point, cost of operation, net present value payback period and revenue cost ratio by using standard test procedures. The cost of operation is 1757.40 ₹/ha, developed harvester can save cost up to 4242.60 ₹/ha over traditional method. The estimated revenue cost ratio, breakeven point, benefit cost ratio, payback period, and net present value were 3.86, 314.47 h/yr,2.41:1, 1.37 yr, and 4.14 duly. The total cost spend for fabrication of harvester was 47,500 ₹. The total amount spend by farmer can return with in one years. The created technique was effectively deployed due to its low cost and ease of usage.

HIGHLIGHTS

- Total cost spent in development of pulse crop harvester was ₹ 47,500 only.
- Benefit cost ratio of pulse crop harvester was 2.4:1.
- Payback period of pulse crop harvester was 1.37 year.

Keywords: Payback period, Breakeven point, Net present value, Benefit cost ratio, Cost of operation, Revenue cost ratio

Pulse word is arrived from Latin 'puls,' it means to 'boil,' as in porridge or thick soup. Pulses have a protein level, which is almost twice of wheat and nearly thrice of rice and are regarded as "poor man's meat" due to their low cost. Globally India is largest producer and consumer of pulses, presently about 25 million hectares of land is under cultivation and producing 19.27 million tonnes annually. Agriculture is India's most important economic industry and the population is predicted to reach 1.69 billion by 2050 according to the Indian Institute of Pulses Research's vision report 2015. To meet the population growth more food must be produced. When compared to developed countries, India's pulse crop yields are low attributed by lack of improved varieties, technologies, and unexpected weather changes. Growing high-yielding pulse crop varieties and improving agricultural machines are two techniques to increase agricultural output.

How to cite this article: Rahaman, S., Hari Babu, B., Ashok Kumar, A., Madhusudhana Reddy, K. and Srinivasa Rao, V. (2024). Economic Analysis and Feasibility of Tractor Operated Pulse Crop Harvester. *Econ. Aff.*, **69**(01): 509-516.

Source of Support: None; **Conflict of Interest:** None

Agricultural mechanization is widely recognized as a valuable alternative input for enhancing agricultural productivity. In comparison to cereal crops, no specific machine or implement has been designed or manufactured for harvesting of pulse crops according to the Indian Institute of Pulses Research and found low mechanization in the domain of pulse crops.

Harvesting takes up around 25 to 30 percent of the total labour needed in crop production, making it a labour-intensive process. If this process is done manually, harvesting pulse crops is a significant issue. It is crucial to harvest crops on time since delaying harvesting causes significant losses in grain and straw due to over-maturing, which causes grains to shatter and cause delays in the preparation of seed beds for next crop. The efficient harvesting process saves time and energy (Rawat *et al.* 2007). The lack of labour during the peak harvesting season causes large post-harvest losses and crop loss due to sudden rains. The need for agricultural labour has grown dramatically as a result of increased cropping density and production of various crops. During the harvesting season, there is a severe lack of labour (Rahman *et al.* 2021). Harvesting is most important, laborious, and human drudgery operation, out of all field operations, which needs 180-200 manhours per hectare for crop harvesting (Salassi and Deliberto, 2010; Veerangouda *et al.* 2010).

Farm mechanization is defined as a set of technologies that ensure timely field operations to increase productivity. Farm mechanization saves time and labour, lowers crop production cost, minimizes harvesting losses, improves product quality, and reduces drudgery. In India, barely 40-45 percent of farm operations are mechanized comparison to developed countries. India's farm power availability is low as 2.025 kW/ha and it is estimated to increase 2.5 kW/ha by 2030 (Mechanization and Technology Division, 2018). In 2016–17, the farm's human power availability was recorded as being 0.091 kW/ha, while the power availability for draught animals decreased from 0.22 to 0.13 kW/ha in 1972 to 2017 (Mehta *et al.* 2019). According to (Surendra Singh *et al.* 2014), availability of average farm power across India reported as 0.30 to 2.02 kW/ha from 1961 to 2014. The level of mechanization varies in each agricultural operations, such as 42 percent for tillage operation, 29 percent for sowing and 34 percent for spraying. When it comes to harvesting, threshing, of wheat or rice have 60-70 percent, whereas other crops such as pulses and oilseed crops have less than 5 percent (Mehta *et al.* 2019). By using efficient harvesting and threshing equipment during unexpected weather conditions 15 to 25 percent of crop damage can be averted.

Agricultural workers and draught animals are decreasing present days. It indicates that improving the level of mechanization aggressively in agriculture sector. The cost of manual harvesting is around 5000 to 6000 ₹/ha and it may vary with location to location and depends on labour availability during peak season. Growth of industries at current scenario makes migration of rural labour to metropolitan areas is main causes to the labour shortage during the harvesting season. Use of agricultural machinery has significantly increased agricultural production by facilitating timely completion of farm operations, lowering production costs, and addressing labour shortages problem (Saruth *et al.* 2014). In the framework of the Indian scenario, farm holdings are small and fragmented. High initial cost of harvesters and capacity, make their use uneconomical or impossible for small and medium-sized farms (Mishra *et al.* 2017). Considering all these factors in the view, a mini-tractor operated pulse harvester has been developed and evaluated for green and black gram crops with the following specific objectives. (1) To develop a mini-tractor drawn front mound pulse crop harvester. (2) To study the economic analysis and feasibility of tractor operated pulse crop harvester.

MATERIALS AND METHODS

Development and Working Principle of Pulse Crop Harvester

The pulse harvester is attached to mini-tractor of 18.5 hp Mitsubishi shakti MT180D tractor. The four major components of the developed machine are attachment frame, hydraulic system, cutter bar assembly and power transmission system. The developed pulse harvester was shown in (Fig. 1). Harvesting is defined as the process of cutting, picking, plucking, digging, or combining these operations. There are four ways to classify the cutting action such as a sharp tool used for slicing action, a rough serrated edge for tearing action, a sharp or dull edge with single element impact to have high velocity and scissors type action with two elements.

Vertical conveyor reaper-cum-windrower is used to cut the crop and form a windrow. It consists of cutter bar and its assembly, star wheels, pressure springs, crop dividers and conveyor belts or chain (Fig. 1). Reciprocating action of cutter bar is generated by crank wheel mechanism. Row crop dividers with help of star wheels guides the crop towards cutter bar and the crop held in vertical position with the help of pressure springs, then vertical held crop conveyed and delivered right side with the conveyor belt with lugs or chain conveying, it makes the windrow.

Table 1: Technical specifications of developed pulse crop harvester

Sl. No.	Components	Specifications
1	Type of crops used	Green gram, Black gram
2	Length of cutter bar	1.2 m
3	Type of cutting unit	Cutter bar with serrated V-shape blades
4	Number of crop dividers	5
5	Power source	18.5 hp
6	Field capacity	0.20 ha/h
7	Overall dimensions	1400 × 945 × 700 mm
8	Height of cut from ground	100 mm
9	Speed of operation	1.5 to 2 km/h
10	Fuel consumption	1.373 L/h

The output shaft gets power from the engine fitted on the reaper, the output shaft transmits the power to crank of cutter bat and also to operate the lugged belt or conveyor chain, this conveyor drives the star wheels. Under the star wheels between the conveying platforms, pressure springs are installed to keep the cut crop upright as it is conveyed out of the machine. The power transmission in case of tractor operated reaper from the PTO shaft to output shaft of reaper through a long shaft beneath the tractor body. Height of crop cut from the ground is regulated by lowering and rising of reaper with hydraulic system of tractor. The technical specification of developed pulse harvester was given in Table 1.

Economic Evaluation of Developed Pulse Harvester

The operating cost of mini-tractor and developed pulse harvester was computed by using standard formulas on hour basis of fixed and variable costs. Depreciation, interest, insurance, taxes, and housing comes under fixed cost, given in (Table 2). For calculating depreciation there are four methods are available such as Units of production, Declining balance, Straight line, and Sum of the years digits. The straight line method was selected to calculate the depreciation of pulse crop harvester. Depreciation is largest component of machines total costs, it estimated by the value of a machine decreases with respect to time, if a machine is used or not (Pagare *et al.* 2019 and Hunt, 2001). Salvage value was usually taken as 10% of capital cost, useful life of commonly used machines under general conditions was taken according to (Sarker *et al.* 2015). Annual interest charge was estimated based on the actual rate of interest (10%) payable over the average investment over the life of machine. The Taxes, housing, and insurance was calculated based on 1% each of the capital investment.

Fig. 1: Developed pulse crop harvester

Fig. 2: Field evaluation of pulse crop harvester

Table 2: Formulas used for estimation of fixed cost

Fixed cost formulas		
Depreciation (D), (₹/h)	$=\frac{C-S}{L \times H}$	Where, S = Salvage Value (₹) C = Capital cost (₹) S = 10 % of Capital cost H = Operating hours per year D = Depreciation (₹/h) L = Useful machine life (year) Interest (i)= 10 %
Interest per hour I, (₹/h)	$=\frac{C+S}{2} \times \frac{i}{H}$	
Insurance, housing & taxes, per hour, (₹/h)	= 3 % of Capital cost	

Source: *(Kumar and Mahadevaiah, 2018; Kingaand Chetem, 2019).*

Table 3: Formulas used for estimation of variable cost

Variable cost formulas		
Fuel cost, (₹/h)	= Fuel consumption Fuel cost per litre	Where, Fuel consumption = 1.373 (L/h) Fuel cost per litre = 100 (₹/L)
Lubrication, (₹/h)	= 25 % of fuel cost	
Repair & maintenance, (₹/h)	= 10 % of capital cost	
Wages of driver, (₹/h)	= 500 ₹/day of 8 h	

Source: *(Kumar and Mahadevaiah, 2018; Kingaand Chetem, 2019).*

The expenditure on lubrication, fuel, wages, repair and maintenance were considered to calculate variable cost, formulas was given in (Table 3). Fuel consumption of any machine depends on horse power of engine and load (draft) during operation and soil condition. The fuel cost was considered as 100 rupees per litre on day rate at the time of field evaluation. Fuel consumption was tested by top fill method during the field evaluation on the harvester. The cost of lubrication was considered 25% of fuel cost, whereas repair and maintenance cost taken as 10% of the capital investment according to the suggestion made by (Hunt, 2001; Barger *et al.* 1987) and wages for operating the tractor operated pulse harvester was takes as 500 rupees for day of 8 hours work. The cost of labour varies based on region from place to place.

Annual use of mini-tractor and machine is considered as 1000 and 350 hours respectively. The operating cost (₹/ha) was estimated on area by multiplying it with machine field capacity. Production of developed pulse harvester is sum of materials cost and labour cost used for fabrication works. The following economic techniques were followed to assess the profitability and feasibility of developed pulse harvested. The five discounting parameters such as net present value, break-even point, payback period, revenue cost ratio and benefit cost ratio was estimated as per standard estimation methods (ISI: 9164-1979).

The project assessment was based on the following assumptions:

1. Technology and methodology followed is constant throughout the project.
2. Constant amount was considered for entire machine life,
3. 12% interest rate was considered according to (ADB, 2013).

Breakeven Point

Break-even analysis, often known as point of no profit, no loss. It is estimated by considering variable and fixed cost and hiring charges of implement. The breakeven point was calculated based on the area covered by the machinery. The minimum area covered by the implement indicates the neither loss nor a profit from work or business. It is the point where no profit is made and no losses. It is calculated by according to (Haquel *et al.* 2014).

$$BEP = \frac{FC}{CH - C} \qquad \ldots(1)$$

Where,

FC = Annual fixed cost, ₹/yr,

CH = Custom hiring charges, ₹/h

= (C + 25 percent over head) + 25 percent profit over new cost

C = Operating cost, ₹/h,

BEP = Breakeven point, h/yr,

Conditions for Acceptance

If Breakeven value < annual utility hours: accept the use of machinery is financially feasible and profitable.

If Breakeven value > annual utility hours: reject the use of machinery is financially not feasible and no profitable.

Payback Period

The time required to recoup investment is known as payback period or it is the period that the investment can be recovered or it is the time taken for an investment to return its original cost through annual cash revenues generated. Payback period indicated in years for machinery and equipment. The payback period may be calculated from the equation according to (Singh *et al.* 2014).

$$PBP = \frac{IC}{ANP} \quad \ldots(2)$$

Where,

ANP = Average net annual profit, ₹/yr,

= (CH – C) × AU

IC = Initial cost of machine, ₹, and

PBP = Payback period, yr,

AU = Annual hours used

Benefit Cost Ratio

The term "benefit cost ratio" refers to the ratio of gross revenue to gross expenditures. For a project investment to be deemed lucrative, the benefit-cost ratio must be at least unity. Complete cost coverage with no surplus profit is represented by the ratio of unity. However, the ratio must be more than unity in order to give some additional return. The benefit cost ratio of developed pulse harvester was calculated on one-hectare basses. To estimate benefit cost ratio, the cost of operation in traditional method and cost of operation by harvester was considered. It is calculated according to (Acharya *et al.* 2020).

$$\frac{B}{C} ratio = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}} \quad \ldots(3)$$

Where

t = time (years)

C_t = Discounted cost incurred

B_t = Discounted benefit from the machine

n = Business age and

r = discount rate (assumed 12% from total investment, following ADB 2013).

Assessment condition:

Net B / C> 1: The benefit cost ratio is economically feasible

Net B / C <1: The benefit cost ratio is not economically feasible

Net Present Value (NPV):

The present value of difference between cash inflow and outflow describes the net present value. It is a financial assessment technique to obtain the returns at certain discount rate and estimated according (Widyatami *et al.* 2020) to the following formula:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} \quad \ldots(4)$$

Assessment criteria:

NPV > 0: The net present value is economically feasible and profitable

NPV < 0: The net present value is economically not feasible and not profitable.

Revenue Cost Ratio

The economic feasibility of developed harvesting unit was estimated by the following mathematical expression according to (Ekawati *et al.* 2021). The revenue cost ratio is the simple expression to know the financial feasibility of any business.

$$\frac{R}{C} ratio = \frac{T_r}{T_c} \quad \ldots(5)$$

Where, T_c = total cost, and

T_r = total revenue

Feasibility assessment criteria

R/C ratio < 1 = infeasible, and

R/C ratio > 1 = feasible

RESULTS AND DISCUSSION

Cost of Operation of Mini-Tractor Operated Pulse Crop Harvester

The mini-tractor taken as 10 years life and annual utility as 1000 hours. Fixed cost and variable costs of a mini-tractor were calculated as 49 ₹/h and 262.12 ₹/h. The total operating cost of the mini-tractor was 311.12 ₹/h. Annual utility taken as 350 hours and life of harvester taken as 8 years. Fixed cost and variable costs of pulse harvester was calculated as 26.79 ₹/h and 13.57 ₹/h. The total operating cost of developed pulse harvester was 40.36 ₹/h.

Total fixed cost is the summation of fixed costs of mini-tractor and pulse harvester which is calculated as 58,376.5 ₹/yr. The total variable cost is combination of both mini-tractor and pulse harvester was calculated as 275.69 ₹/h. The total operating cost of mini-tractor and pulse harvester was calculated as 351.48 ₹/h. But in traditional method of harvesting operation for one hectare requires 6000 ₹/ha. The cost of operation by developed pulse crop harvester was 1757.40 ₹/ha to complete the harvesting operation in hectare. By adopting pulse harvester, a farmer saves 4,242.60 ₹/ha over traditional method. (Nadeem *et al.* 2018) reported cost of operation by paddy harvester (reaper) was 394.53 ₹/hand 1972.65 ₹/ha. It was observed that by using harvester for crop harvester, savers half of the farmers investing amount for harvesting operation.

Estimation of Breakeven Point

Breakeven point was calculated by graphical representation between custom hiring cost verses total cost of developed harvester. Joining of two lines indicates the number of working hours necessary for break-even. Farmer gets benefitted by owning a machine when breakeven value is lower the annual use, if it is more it leads to loss, in such a condition custom hiring is the better option. The total operating cost line "*y* = 275.69x + 58377" and the total custom hiring cost line is "y = 461.32x". In the equations the letter "x" denotes the number of operating hours of harvester. From (Fig. 2) breakeven point of harvester was found to be 314.47 hours per year. (Amponsah *et al.* 2017) was estimated breakeven point between total cost and hours used per year, representing breakeven point at 342 h of machine use of paddy field harvesting, from Compare and contrast of findings it shows that same trending of breakeven point was observed.

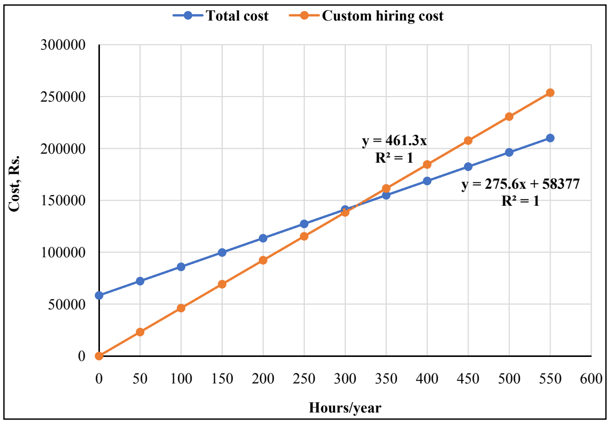

Fig. 2: Breakeven point representation of pulse crop harvester

Estimation of Payback Period

The payback period for pulse harvester was estimated according to cost of machine, yearly mean net profit and yearly machine utility. Obtained value of payback period for pulse crop harvester was 1.37 years. (Hasan *et al.* 2021) found payback period of 1.15 years for small combine harvester. It was observed that within one and half years a farmer gets back their investment for the purchase or fabrication pulse crop harvester or any other grain (paddy, wheat) harvesters.

Estimation of Benefit Cost Ratio

Obtained value of pule harvester was 2.41:1, it depicts that, two times the farmer can get profit by using the developed pulse crop harvester. The assessment criteria for operation of harvester were based on two conditions: (i) If estimated value of benefit cost ratio is greater than 1, the business or operation is financially feasible (ii) If estimated value of benefit cost ratio is less than 1, the business or cost of operation is financially not feasible. Cost of operation by pulse harvester was found to be 1757.40 ₹/ha and cost of operation in traditional method was 6000 ₹/ha. By using pulse harvester, a farmer save about 70.71% over traditional method of harvesting. By adopting mini-tractor drawn pulse harvester, farmer saves 4,242.60 ₹/ha directly over manual method of harvesting operation. (Acharya *et al.* 2020) was estimated benefit cost ratio 2.89:1 for rice harvester. The benefit generated by the harvester or any agricultural machinery largely depends on the amount saving over operating cost of traditional method. Previous researchers were reported a minimum of 2 times the profit is generated by harvesting machinery over the traditional method of harvesting.

Estimation of Net Present Value

The estimation of net present value of pulse crop harvester was found to be 4.14, assessment criteria for the net present value is that, if the calculated value of net present value is greater than zero then the running a business or operation of the developed harvester is feasible and profitable in the farmer point of view. In the second condition of assessment criteria, calculated value is lower than zero then running a business or operation of the developed harvester is not feasible and not profitable. Based on the estimated value of net present the developed pulse crop harvester was feasible to use by farmer. (Widyatami *et al.* 2020) reported net present value is positive, it shows that use of harvester is feasible.

Estimation of Revenue Cost Ratio

The estimation of revenue cost ratio of pulse harvester was 3.86, the feasibility assessment criteria is that, if the estimated value of revenue cost ratio is greater than one, it is feasible to purchase machinery and feasible to use on their own farm or a farmer can give on custom hiring basis and if calculated value of revenue cost ratio value indicating less than one, then the use or adoption of pulse harvester is not feasible. The estimated value of revenue cost ratio indicated that a farmer can generate revenue nearly by four times the investment cost. Based on the estimations a pulse harvester is highly recommended to use by farmers. (Ekawati *et al.* 2021) reported revenue cost ratio for agricultural machinery and implements more than unity and stated that using a machinery on their own farm use as well as custom hiring business is feasible. Various economical aspects of developed pulse crop harvester were presented in (Table 4).

Table 4: Various economical aspects of pulse crop harvester

Sl. No.	Economic factors	Obtained value
1	Total fixed cost per year, ₹	58,376.5
2	Total operating cost, ₹/h	351.48
3	Total variable cost, ₹/h	275.69
4	Breakeven point, ha/yr	106.29
5	Manual harvesting cost, ₹/ha	6000
6	Custom hiring cost, ₹/h	461.32
7	Breakeven point, h/yr	314.47
8	Payback period, years	1.37
9	Cost saving over existed methods, ₹/ha	4,242.60
10	Cost saving, Percent	70.71
11	Total area covered per year, ha/yr	70
12	Total operating cost, ₹/ha	1757.40
13	B:C ratio	2.41:1
14	Net present value	4.14
15	Revenue cost ratio	3.86

Source: *Calculated based on formulas mentioned.*

CONCLUSION

The cost of operation was 1757.40 ₹/ha, by using pulse harvester, a farmer can save up to (4,242.60 ₹/ha) 70.71 percent as compared traditional method of harvesting. The breakeven point was reported 314.47 h/yr, Farmer gets benefitted by owning a machine when the value of breakeven point is lower than the annual utility, if it is more it leads to loss, in such a condition custom hiring is the better option. Obtained of payback was 1.37 years, it shows that farmer get back their investment within 1.37 years by owing pulse harvester. The obtained value of benefit cost ratio was 2.41:1, it shows that a farmer has double the profit by using pulse harvester. The estimation of net present value was found to be 4.14, which indicates that use of pulse crop harvester feasible and profitable in the farmer point of view. The estimation of revenue cost ratio was 3.86 it shows that a farmer can generate revenue nearly by four times the investment cost. The suggestions for future study are other agricultural machinery can also be investigated to test feasibility analysis.

ACKNOWLEDGEMENTS

Author(s) acknowledges financial support from

Dept. of Farm Machinery & Power Engineering, Dr. NTR College of Agricultural Engineering, Bapatla, Acharya N.G. Ranga Agricultural University, Lam, Guntur.

REFERENCES

Acharya, P., Regmi, P.P., Gauchan, D., KC, D.B. and KC, G.B. 2020. Benefit Cost Analysis of Small Farm Machineries Used for Rice Cultivation in Nepal. *Int. J. Applied Sciences and Biotechnology*, **8**(4): 448-453.

ADB, 2013. *Cost benefit analysis for development: a practical guideline*. Mandaluyong city, Philippines, Asian Development Bank.

Amponsah, S.K., Addo, A., Dzisi, K.A., Moreira, J., and Ndindeng, S.A. 2017. Performance Evaluation and Field Characterization of the Sifang Mini Rice Combine Harvester. *Applied Engineering in Agriculture*, **33**(4): 479-489.

Ekawati, Ellyta, and Sugiardi S. 2021. Economic Feasibility Analysis of Service Business of Agricultural Equipment and Machinery in Kubu Raya Regency, Indonesia. *Earth and Environmental Science, The 7th International Conference on Sustainable Agriculture and Environment, In IOP Conference Series*, **637**(1).

Hasan, M.K., Tanaka, T.S., Ali, M.R., Saha, C.K. and Alam, M.M. 2021. Harvester Evaluation Using Real-Time Kinematic GNSS and Hiring Service Model. *AgriEngineering*, **3**(2): 363-382.

Haquel, M.A., Alaml, M. and Sarker, T.R. 2014. Break Even Analysis of Farm Machineries Available in Bangladesh for Selected Farm Operations. *J. Agricultural Engineering, Institution of Engineers*, **41**(2): 11-17.

Indian Institute of Pulse Research. 2015. *Vision 2050*. Indian Council of Agricultural Research, Kanpur.

ISI: 9164-1979. *Guide for estimating cost of farm machinery operation*. Indian Standards Institution, New Delhi.

Kinga, N. and Chetem, W. 2019. An Economic Analysis of Government Custom Hiring Services for Different Farm Machineries In Bhutan. *SAARC Journal of Agriculture*, **17**(2): 93-101.

Kumar, P.R. and Mahadevaiah, G.S. 2018. Breakeven Analysis of Custom Hiring Service Centres Operating in Agriculture: An Economic Study in Karnataka. *International Research Journal of Agricultural Economics and Statistics*, **9**(1): 141-148.

Mechanization and Technology Division. 2018. *Monitoring, concurrent evaluation and impact assessment of sub-mission on agricultural mechanization*. Department of Agriculture, Ministry of Agriculture and Farmers' Welfare Government of India, New Delhi.

Mehta, C.R., Jena, P.C., Chandel, N.S. and Anamika, J. 2019. Indian Agriculture Counting on Farm Mechanization. *Agricultural Mechanization in Asia, Africa and Latin America.*, **50**(1): 84-89.

Mehta, M.L., Verma, S.R., Misra, S.K., and Sharma, V.K. 2019. *Testing and evaluation of agricultural machinery*. New Delhi: Daya Publishing House India Pvt Ltd.

Mishra, P.K., Singh, M., Gill, J.S., Mandal, B., and Patel, B. 2017. Economic Analysis and Feasibility of Tractor Operated Cotton Harvesters. *Ind. J. Economics and Development.*, **13**(4): 761-766.

Nadeem, M., Jabbar, A., Baig, F., Ghani, H.U., Akram, W. and Ikram, K. 2018. Cost Analysis of Engine Operated Reaper and its Comparison with Tractor Mounted Reaper. *J. Global Innovations in Agricultural Sciences*, **6**(1): 1-6.

Pagare, V., Nandi, S. and Khare, D.K. 2019. Appraisal of Optimum Economic Life for Farm Tractor: A Case Study. *Economic Affairs*, **64**(1): 117-124.

Rahman, M.S., Sujan, M.H.S., Sherf-Ul-Alam, M. and Kabir, M.H. 2021. Adoption and is-adoption of farm mechanization in Bangladesh: Case of rice-wheat thresher. *Emirates J. Food and Agriculture*, **33**(12): 1000-1007.

Rawat, S.N., Verma, M.R., Goyal, S.K. and Dave, A.K. 2007. Cost Economic Evaluation of Zero Till Fertilizer cum Seed Drill vs Conventional Method of Sowing, *Progressive Agriculture*, **71**(2): 161-162.

Salassi, M.S. and Deliberto, M.A. 2010. *Estimating rice combine harvest cost: Performance rate, capital cost, operating cost* (Staff Report No. 2010-08). Department of Agricultural Economics and Agribusiness, Louisiana State University, Agricultural Center, Baton Rouge, Louisiana. USA.

Sarker, T.R., Alam, M., Haque, M.A. and Zaman, K.S. 2015. An Analysis of Break-Even Acreage of Farm Machineries for Postharvest Operations Available In Bangladesh. *Bangladesh J. of Agricultural Engineering*, **26**(1&2): 61–71.

Saruth, C., Lytour, L. and Sinh, C. 2014. Status and prospect of agricultural mechanization in cambodia. *Economic and social commission for Asia and the pacific, The United Nation, Bangkok, Thailand*.

Singh, R.S., Singh, K. and Dubey, A. 2014. Custom Hiring Business Model and Decision Support System of Agricultural Machinery. *Agricultural Engineering Today*, **38**(4): 31-36.

Singh, S., Singh, R.S. and Singh, S.P. 2014. Farm Power Availability on Indian Farms. *Agricultural Engineering Today*, **38**(4): 44-52.

Veerangouda, M., Sushilendra, S., Prakash, K.V. and Anantachar, M., 2010. Performance Evaluation of Tractor Operated Combine Harvester. *Karnataka J. Agricultural Sciences*, **23**(2): 282-285.

Widyatami, L.E., Yusuf, C. and Wiguna, A.A. 2020. Business Feasibility Analysis of Agricultural Equipment and Machinery Rental Services Unit (UPJA) in Rogojampi Sub-district of Banyuwangi Regency, *Earth and Environmental Science*, **411**(1): 1-7.