ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Benefit Cost Analysis of Adoption of Small Farm Machineries for Rice Cultivation in Nepal

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Article Information

Received: 11 October 2020
Revised version received: 23 November 2020
Accepted: 25 November 2020
Published: 28 December 2020

Cite this article as:
P. Acharya et al. (2020) Int. J. Appl. Sci. Biotechnol. Vol 8(4): 448-453. DOI: 10.3126/ijasbt.v8i4.31928

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Peer reviewed under authority of IJASBT

Abstract

A study was conducted in Jhapa, Sunsari and Bardiya district of Nepal to assess the benefit cost (BCA) analysis of small farm machineries (transplanter, reaper and power tiller) used for rice cultivation. Out of total respondents of 274 under mechanized farm category selected using Raosoft Software of sample size determination, 74% (20) reaper owner, 67% (20) power tiller owner and 100% (09) transplanter owner were selected for benefit cost analysis using simple random sampling. Analysis showed that benefit-cost ratio of reaper and power tiller was higher than (2.89) than transplanter (1.61). The investment on reaper and power appeared to be profitable because of their higher Benefit Cost ratio and internal rate of return, and lower payback period. The results of sensitivity analysis showed that investments in reaper and power tiller would be profitable even if decrease in benefit or increase in cost is by 20%. However, in case of transplanter, the internal rate of return would be less than the discount rate when benefit decreases by 20% and cost increases by 20%. Due to high investment at the initial stage, the payback period was longer and IRR was also less than 30% per annum in transplanter, which indicated that investment would not be made for transplanter unless price of transplanter is lowered through regulation of price and provision of subsidy. It is suggested to motivate farmers for adoption of small farm machineries in rice cultivation through provision of differentiated rates of subsidy and technical capacity build up.

Keywords: B/C ratio; NPV; IRR; Payback period; Sensitivity analysis; Subsidy

Introduction

Rice is the number one crop in Nepal in terms of area, production and contribution to Gross Domestic Product (GDP), Agricultural Gross Domestic Product (AGDP) and livelihood of the people. (Regmi, 2017). With the area of about 1.49 million hectare and production of 5.61 million tons, the contribution of rice to total GDP and AGDP are about 20% and 7% respectively (CDD, 2015). Rice is labor intensive crop and thus requires large number of labors during various farm operations (Bhandari *et al*. 2015; Dhital, 2017). The rice productivity is greatly affected by labor scarcity during crop establishment (Liu *et al*., 2017). For the successful crop production and higher productivity,

the timeliness of farm operations is important and use of improved implements and machineries play vital role for undertaking the farm operation in time. In this context, farm mechanization can help to address shortage of labor, ease drudgery, enhance productivity and the timeliness of agricultural activities, to promote efficiency in resource use (ESCAP, 2018).

In recent years, farmers have been using various types of farm machineries for rice cultivation. The use of farm machines is more concentrated in Tarai districts as compared to hills and high hills. The use of tractors and threshers have already been established as necessary equipment for tillage and threshing and farmers have been habituated to adopt them. However, the small farm machineries like reaper, power tiller, transplanters have been recently introduced since the last few years and the financial analysis of these machines are still remained to be explored. Thus, the present study was conducted to assess the benefit cost analysis of small farm machineries (reaper, power tiller and transplanter) used for rice cultivation in the selected districts of Nepal.

Materials and Methods

Study Area

The study was conducted in Jhapa, Sunsari and Bardiya districts of Nepal during December 15, 2018 – April 15,2019. Jhapa and Sunsari districts were two Terai districts of province no. 1 and Bardiya was one of the Tarai districts of Lumbini province. These three districts were among the most potential districts in rice production in Nepal. The three districts share 12.6% and 14.1% to total area and production in Nepal, respectively (MoALD, 2020). These districts were also the command areas of Rice Zone and Super Zone units of Prime Minister Agriculture Modernization Project (PMAMP) which is a government owned project being implemented to facilitate for industrialization of rice sector via promotion of mechanization as one of the strategic interventions.

Within the selected districts, respondents from one local government administrative unit from Jhapa (Kachankawal Rural Municipality), two local units from Sunsari (Duhabi Municipality and Gadi Rural Municipality) and two local units from Bardiya (Rajapur Municipality and Geruwa Rural Municipality) were selected for taking data through structured and semi-structured questionnaires. The heavy type of machineries like tractors and threshers are already popular in in these parts of the Terai region of Nepal. However, use of small farm machineries like transplanter, reaper and power tillers is getting popularity in recent years. In the study site, walking behind type of transplanter, reaper attached in power tiller and 20-22 HP power tillers were popular. Hence, the study was conducted on assessing the financial analysis of small farm machineries (reaper/transplanter/power tiller) in rice zone and super zone command areas of these three districts.

Sampling Design

Multistage random sampling technique was adopted for the selection of study area. The rice growers of selected municipalities were considered to be in sampling frame. The rice growing farms were divided into two categories i.e. Mechanized and Traditional rice farms. Raosoft software of sample size determination was used to select 274 mechanized and 220 traditional farms from the total respondents of 494 to study economics of farm mechanization in rice farming in Nepal. The respondents having ownership of small farm machineries constituted the sampling frame of this study. Among respondents from mechanized farm category, households having ownership of power tiller, reaper (Power tiller attached) and transplanter (Walking behind type) were 35 (12.77%), 27 (9.85%) and 9 (3.28%) respectively. Among them 20 power tiller owners (67%), 20 reaper owners (74%) were selected using simple random sampling and all transplanter owners (100%) were selected using census method for assessment of financial analysis of small farm machineries for rice cultivation.

Analytical Technique

The project appraisal technique has been followed to find out the profitability of small farm machineries for owner point of view. Four alternative discounting measures: benefit-cost ratio (BCR), net present value (NPV), internal rate of return (IRR) and payback period are commonly applied for project appraisal (Gittinger, 1994).

This appraisal was based on the following four assumptions:

(1) All the devices were purchased with cash;

(2) Operation technology was unchanged throughout the project life;

(3) Prices of all input and outputs were given and constant throughout the project life and

(4) Interest rate of 12% - assumed for calculating BCR and NPV following ADB (2013).

Benefit Cost Ratio

Benefit-cost ratio (B/C ratio) is the ratio of benefits to costs (expressed either in present or annual worth). It is simple ratio of benefit and cost of investment. In the current study benefit cost ratio of farm machines were calculated using the following formula:

$$\frac{B}{C} ratio = \sum_{t=1}^{t} \frac{Bt}{(1+r)^t} / \sum_{t=1}^{t} Ct/(1+r)^t$$

Where,

Bt = Discounted benefit from the machines (NRs.)

Ct= Discounted cost incurred (NRs)

t= time (years)

r= discount rate (assumed 13% following ADB (2013)

Decision criteria: If, B/C ratio > 1, Accept investment, B/C ratio < 1, Reject investment, B/C ratio = 1, Indifferent

Net Present Value

Net Present Value (NPV) is the difference between the present value or the present value of cash inflow and the present value of cash outflow. NPV method of financial appraisal shows the return received from a project at a certain discount rate (Mulyawan, 2015). The Net Present Value of major farm machines used in rice farming was calculated using the following equation:

$$NPV = \sum_{t=1}^{t} (B_t - C_t)/(1+r)^t$$

Where,

NPV = Net Present value (NRs)

B_t = Discounted revenue stream (NRs)

C_t = Discounted cost stream (NRs.)

t= Time period (years)

r= Discount rate and is considered 12% following ADB (2013).

Decision Criteria: If, NPV > 0, Accept investment; NPV < 0, Reject and NPV = 0, Indifferent

Internal Rate of Return

The Internal rate of return (IRR) is the value of discount factor/discount rate at which net present value of an investment becomes zero. Therefore, if IRR exceeds the cost of capital of the investment (discount rate/rate of borrowing), such an investment is considered to be worth doing (Paudel *et al*., 2018). The IRR of farm machines used in rice cultivation was calculated using the following formula:

$$\text{IRR} = \text{LDR} + \frac{(\text{Differnce between two discount rate X NPV at LDR})}{\text{Absolute diffence between NPV at two discount rate}}$$

Where,

LDR = Lower Discount rate

Decision Criteria:

If, IRR > cost of capital/discount rate, Accept investment

If, IRR < cost of capital/discount rate, Reject

If, IRR =Cost of capital/discount rate, Indifferent

Discounted Payback Period

Discounted payback period method is basically the same as the calculation of the payback period method, which is to calculate the payback period for an investment. The DPP method uses net cash flow that has been changed to its present value (Sjahrial, 2007). Payback period is the length of time required to recover the cost of an investment (Boardman *et al*., 1982). The payback refers to the time period within which the costs of investment can be covered by revenues. In other words, it is the length of time required for the stream of cash proceeds produced by an investment to equal the initial expenditure incurred.

In this study, the Payback period of the farm machines used in rice cultivation was assessed using the following formula:

$$Pay\ back\ period = \frac{Investment\ (total\ initial, NRs)}{Net\ Benefit\ (NRs/Year)}$$

Results and Discussion

Ownership of Machines

Ownership of machines provide flexibility to farm households to carry out farm operations in timely manner. The findings of the survey showed that 31.87% of the respondents in Jhapa, 34.07% in Sunsari and 39.13% of respondents in Bardiya had at least one of the farm machines/equipment used for rice cultivation (Table 1). In total, 35.04 % of the respondents in mechanized rice farms category had their own machines. None of the respondents were found to have all the enlisted three equipment in single household. Farmers were found to have all types of heavy and small farm machineries used for rice cultivation in study sites. However, the number of small farm machineries were in larger number as compared to heavier one.

Status of Ownership of Machines

There were altogether 734 farm tools and implements owned by farmers of mechanized rice farms. Among three study districts, respondent farmers of Bardiya district had maximum number of farm implement (276) followed by Sunsari (254) and Jhapa (204) (Table 2). Out of total heavy machines (tractor/combine) owned, 8.03% respondents had their own tractors and 1.09% of them had combined machines. Similarly, 12.77% of the respondents had their own power tillers to be used for rice cultivation. Only 6.20% of the respondents had their own transplanters and 9.85% of the respondents had own reapers which could be used after attaching into power tillers or tractors. The details of ownership of machineries in study sites is given in the Table 2.

Table 1: Ownership of machines by the respondent farm households

Ownership	Jhapa (N=91)		Sunsari (N=91)		Bardiya (N=92)		Total (N=274)	
	No.	%	No.	%	No.	%	No.	%
Yes	29	31.87	31	34.07	36	39.13	96	35.04
No	62	68.13	60	65.93	56	60.87	178	64.96
Total	91	100.00	91	100.00	92	100.00	274	100.00

(Field survey, 2019)

Table 2: Ownership of farm machines by respondent farm households

Machines	Jhapa (N=91)		Sunsari (N=91)		Bardiya (N=92)		Total (N=274)		
	No.	HH	No.	HH	No.	HH	No.	HH	% HH
Laser Land leveler	3	3	4	4	3	3	10	10	3.65
Leveler Normal	14	13	18	16	19	19	51	48	17.52
Tractor	6	4	8	6	8	7	22	17	6.20
Disc harrow	6	6	9	9	11	11	26	26	9.49
Cultivator	6	6	8	9	8	8	22	23	8.39
Power tiller	14	10	15	12	17	13	46	35	12.77
Rotavator	3	3	3	3	4	4	10	10	3.65
Line maker	5	5	9	9	12	12	26	26	9.49
Walk behind transplanter	3	3	3	3	3	3	9	9	3.28
Riding type transplanter	2	2	2	2	1	2	5	6	2.19
Manual transplanter	1	1	2	2	0	0	3	3	1.09
Seed drill	6	6	8	8	10	10	24	24	8.76
Drum seeder	5	5	9	9	11	11	25	25	9.12
Happy seeder	2	2	2	2	1	1	5	5	1.82
Power weeder	7	4	10	7	31	21	48	32	11.68
Hand weeder	25	22	35	32	31	27	91	81	29.56
Power sprayer	17	17	21	21	23	23	61	61	22.26
Knap sap sprayer	20	20	23	23	25	25	68	68	24.82
Pump set	23	23	20	18	14	14	57	55	20.07
Brush cutter reaper	5	3	6	4	4	4	15	11	4.01
Reaper	8	8	9	9	10	10	27	27	9.85
Combine	1	1	1	1	1	1	3	3	1.09
Tractor driven thresher	9	7	11	8	15	11	35	26	9.49
Winnower	15	15	19	19	22	20	56	54	19.71
Total	**204**		**254**		**276**		**734**		

(Field survey, 2019)

Financial Appraisal of Small Farm Machineries Used in Rice Cultivation

The heavy type of machineries like tractors and threshers are already popular in Terai region of Nepal. However, use of small farm machineries like transplanters, reapers and power tillers is getting popularity in recent years. The financial analysis (Benefit Cost Analysis-BCA) helps the farmers and the entrepreneurs to make right investment decisions. In the study site, walking behind type of transplanters, reapers attached in power tillers and 20-22 HP power tillers were popular. Thus, financial analysis of walking behind type transplanter was assessed. The machine owners were asked to give details on cost incurred and benefits received from those small farm machines used for rice cultivation.

In this analysis, the cash flow of transplanters/reapers/power tillers (22 HP type) were accumulated based on the production seasons (main season and spring season rice). Farmers have been adopting these machineries for rice farming since last few seasons., The study assumed that, the farmer will earn and invest the same amount that he is earning and expending as in the last 4 seasons for next some seasons. The condition might differ for different farmers depending upon the area coverage of rice by these small farm machines owner and the cash flow and the cost associated with those machines. To generalize the situation for overall transplanter/reaper/power tiller owners, sensitivity analysis was done taking the bench mark of cost increment by 20%, benefit decrease by 20% and cost increase by 20% and benefit decrease by 20%.

Benefit Cost Analysis of Transplanter

Benefit Cost analysis showed that the NPV of investing in a transplanter that costs NRs 448,324/- (average costs of walk behind type of transplanter), which transplants 0.66 hectares of rice field in 3 hours, was NRs 452,743.62 at 12% of discount rate. The B/C ratio of such transplanter was only 1.61 with 24% IRR and payback period of 2.75 years. This indicates that time required to incur initial investment takes more than two and half years (Table 3). Since, the B/C ratio is just more than one and pay back periods was higher, it can be concluded that it's very difficult to make farmers adopt rice transplanter unless the initial cost of transplanter is lowered. This indicated that farmers are no more going to invest in transplanter unless subsidy is provided. For this, government should make appropriate policies of support and subsidy for rice transplanters. The subsidy will encourage farmers to invest in transplanters. Similarly, sensitivity analysis showed that decrease in benefit or increase in cost of transplanters can enforce entrepreneur just to be away from adopting transplanters because it would not be profitable as expected. In fact, this was the reason for transplanters not being popular in the study sites even under the process of custom hiring services operated by group/cooperatives.

Table 3: BCA of a transplanter owner farmers

Financial description	Statistics
B/C ratio	1.61
NPV (at 12%) NRs	452,743.62
NPV (at 15%) NRs	387,201.37
IRR (%)	24%
Pay Back Period (Years)	2.75
If cost increased by 20%	
B/C ratio	1.17
NPV (at 12%) NRs	340,063.68
NPV (at 15%) NRs	282,821.30
IRR (%)	20%
If benefit decreased by 20%	
B/C ratio	1.09
NPV (at 12%) NRs	164,925.53
NPV (at 15%) NRs	121,971.91
IRR (%)	13%
If cost increased by 20% and benefit decreased by 20%	
B/C ratio	0.74
NPV (at 12%) NRs	52,245.59
NPV (at 15%) NRs	17,591.84
IRR (%)	8%

(Calculated by authors, 2020) Note: 1 USD = 117.50 (As of 24th October 2020)

Benefit Cost Analysis of Reaper Used for Rice Harvesting

BCA analysis showed that the NPV of investing in a reaper that costs NRs 64,651 /- (average costs of power tiller attached reaper), which can harvest 54 hectares of rice field in two seasons and can harvest 0.66 hectares of rice in 2.5 hours, was NRs 422,541.93 at 12% of discount rate. The B/C ratio of such transplanter was 2.89 with 123% IRR and payback period of about 1 year (Table 4). Since, the B/C ratio was good and pay-back period and IRR were encouraging, reaper can be a well-established enterprise. Similarly, sensitivity analysis showed that a reaper owner when provides services can have short payback period and can develop an entrepreneurship in small scale machinery. The details of BCA of Reaper used for harvesting of rice crop is shown in the Table 4.

Benefit Cost Analysis of Power Tiller Used for Tillage

BCA analysis showed that the NPV in a power tiller that costs NRs 196,450/- (average costs of 22 HP Power tiller used in study sites), which is generally used for tillage and puddling of rice field can do tillage at the rate of 3 hours/hectare, was NRs 619,719.34 at 12% of discount rate (Table 5). The B/C ratio of such power tiller used for rice farming purpose was 2.32 with 65% IRR and payback period of about one and half a year. These types of power tillers were extensively used especially for puddling of rice field and also for tillage purpose in study sites. Since, the B/C ratio was good and pay-back period and IRR were encouraging, power tiller can be well established enterprise. Similarly, sensitivity analysis showed that investment in power tiller would be even profitable and acceptable business when increase in cost or decrease in benefit from power tiller happens. Thus, power tiller owner when provides services can have short payback period and can develop an entrepreneurship in small scale machinery. However, it could be difficult for the farmers with low-income group to afford this amount of money to purchase power tiller and thus government should help farmers through subsidy mechanism or establishment of custom hiring services centers to promote this machine for rice farming. The details of BCA of power tiller for rice farming is shown in the Table 5.

Table 4: BCA of reaper owner farmers

Financial description	Statistics
B/C ratio	2.89
NPV (at 12%) NRs	422,541.93
NPV (at 15%) NRs	389,235.38
IRR (%)	123%
Pay Back Period (Years)	1.14
If cost increased by 20%	
B/C ratio	2.24
NPV (at 12%) NRs	389,069.05
NPV (at 15%) NRs	358,122.15
IRR (%)	114%
If benefit decreased by 20%	
B/C ratio	2.11
NPV (at 12%) NRs	292,362.36
NPV (at 15%) NRs	268,246.98
IRR (%)	90%
If cost increased by 20% and benefit decreased by 20%	
B/C ratio	1.59
NPV (at 12%) NRs	258,889.48
NPV (at 15%) NRs	237,133.76
IRR (%)	81%

(Calculated by authors, 2020) Note: 1 USD = 117.50 (As of 24th October 2020)

Table 5: Benefit/cost analysis of power tiller owner farmers

Financial description	Statistics
B/C ratio	2.32
NPV (at 12%) NRs	619,719.34
NPV (at 15%) NRs	564,804.64
IRR (%)	65
Pay Back Period (Years)	1.46
If cost increased by 20%	
B/C ratio	1.77
NPV (at 12%) NRs	550,583.53
NPV (at 15%) NRs	500,674.64
IRR (%)	60
If benefit decreased by 20%	
B/C ratio	1.66
NPV (at 12%) NRs	389,573.62
NPV (at 15%) NRs	351,164.87
IRR (%)	46
If cost increased by 20% and benefit decreased by 20%	
B/C ratio	1.21
NPV (at 12%) NRs	320,437.81
NPV (at 15%) NRs	287,034.87
IRR (%)	40

(Calculated by authors, 2020) Note: 1 USD = 117.50 (As of 24th October 2020)

Conclusion

The investment decision on transplanter would be based on initial price of transplanter. Due to high investment at the initial stage, the payback period was longer and IRR was also less than 30% per annum. Thus, lack of technical aspects in operating transplanter in rice field on the one hand and higher initial cost of machine on the other hand would definitely hinder the promotion of transplanter among small farmers in the study site. So, it is strongly recommended to devise appropriate subsidy policy for promoting transplanters along with making technical guideline to operate transplanters by the government institutions. The investment on reapers and power tillers would be profitable for their higher Benefit-Cost ratio and IRR, and lower payback period. However, it could be difficult for the farmers with low-income group to afford this amount of money to purchase power tiller and thus government should help farmers through subsidy mechanism or establishment of custom hiring services centers to promote those machines for rice farming. The investment decision on reaper would be profitable with higher benefit cost ratio, shorter payback period and higher IRR. Thus, it is suggested to formulate policies to programs to promote small farm machineries like reapers for harvesting of rice and for addressing the need of small holder farmers to harvest rice crop.

Author's Contribution

Prakash Acharya designed the research plan; performed experimental works & collected the required data. Punya Prasad Regmi, Devendra Gauchan, Dilli Bahadur KC, Gopal Bahadur KC analysed the data; Prakash Acharya prepared the manuscript. All authors critical revised, finalized and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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