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RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF COST, RETURN, PROFITABILITY AND LABOR USE IN MECHANIZED AND TRADITIONAL RICE FARMS IN NEPAL

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ABSTRACT

The main objective of the study was to assess cost, returns and labor use status between mechanized and traditional rice farms in the Tarai of Nepal. The study was conducted using multistage sampling technique in Jhapa, Sunsari and Bardiya districts covering 274 mechanized and 220 traditional rice farms. Farm budget analysis was used to compute the cost and yield returns from both type of rice farms. The study revealed that the per hectare average human labor used by traditional farm was significantly higher (141.6 man days/hectare) than mechanized rice farm (72.7 man days/per hectare). The per hectare average machine hour used in mechanized farm was 14.0 hours. Number of bullock labor required in traditional rice farm was more than 4 times higher than in mechanized rice farm and was significant. Per hectare total cost of production in mechanized and traditional farms was NRs 85,434.6 and NRs. 95,993.6, respectively and the mean difference was significant. The mechanized rice farm had significantly higher income (NRs. 112711.1/ha) than traditional rice farm (NRs.102064.9/ha). The benefit csot ratio per hectare was significantly higher in mechanized farm (1.32) as compared to traditional(1.06). The variable cost saved in mechanized farm in comparison to traditional rice farm was NRs. 20,366.8 per hectare, which was 24.80 % and was significant. The study indicated that the use of farm machines for rice cultivation would significantly save the human labor cost, reduce cost of production, increase the yield thereby removing drudgery; addressing the labor shortage issues and making mechanized rice farm more profitable.

KEYWORDS

Mechanization, Traditional farm, Labor, Cost, Yield, Return.

1. INTRODUCTION

Nepal is an agricultural country where almost two-thirds of its population is engaged in agriculture, and agriculture contributes almost one-third of the national gross domestic product (MoAD, 2016). In recent years, Nepalese agriculture has experienced an accelerating trend of labor out-migration, particularly to middle-east countries in search of better job opportunities (Maharjan et al., 2013a). This has created acute labor shortages in the agriculture sector that has affected timely crop establishment and other crop cultivation practices (ILO, 2017; Maharjan et al., 2013a, 2013b). This situation has contributed to rising rural wage rates (Wiggins and Keats, 2014; Wang et al., 2016). While the rising rural wage rates are desirable for agricultural workers, significantly negative impacts on farm enterprise profitability and productivity are common. Furthermore, despite persistent low-crop productivity and high food insecurity, the agricultural area remaining fallow due to rising labor prices in Nepal (Khanal, 2018; Khanal et al., 2015; Maharjan et al., 2013b; Prabakar et al., 2011). In this context, policy makers in Nepal have identified mechanization as a vital component of agricultural sector growth with increased efficiency in farm productivity and increased return to factor of production.

Rice is placed at the first rank among cereal crops in terms of area, production and contribution to Gross Domestic Production (GDP), Agricultural Gross Domestic Product (AGDP) and livelihood of the people in Nepal (Regmi, 2017). Rice contributes about 20% and 7% to AGDP and GDP respectively and also supplies about 40% of the food calorie intake in Nepal (CDD, 2015). Currently, from the area of 1.49 million hectares of land, 5.61 million metric tons rice is produced in Nepal and the Terai region of the country, which shares more than 70% in term of area and production in Nepal (MoALD, 2019). However, the trend of importing rice (milled and grain) has increased from 487 thousand metric ton to 769,000 metric tons in terms of quantity while the value has almost doubled from NRs.16 billion to NRs.32 billion in the last 6 years (DoC, 2019). Thus, this situation clearly demands the calls for improving yield of rice to ensure food and nutritional security in Nepal.

Similarly, cost of production of rice has increased mainly due to increase

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in price of production inputs like seed, fertilizer and labor with 60-65% share of human labor and bullock/tractor use to total cost of production to be (Aryal and Bhandari, 2017). Increase wage rate of labor has forced farmers to leave their rice field fallow, which directly has affected the production of rice. Similarly, shortage of labor has affected in timely crop establishment and timely farm operations as well. This indicates, rice farming seems to be full of drudgery with higher cost of production incurred. In this context, farm mechanization can be the best option to address the issue of labor shortage and high cost of production. The objective of farm mechanization is to enhance overall productivity and lower the cost of production (Verma, 2008; Aryal and Bhandari, 2017). The study was conducted with the objective of making comparative analysis of traditional and mechanized rice farms with regard to labor use, cost and profitability. The study is expected to present clear pictures on cost, benefits, profitability associated in rice farming in rice farms using agricultural machines and without using agricultural machines.

2. Materials and Methods

2.1 Study area

The study was conducted in Jhapa, Sunsari and Bardiya districts of Nepal during 2018/19. 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 district in rice production in Nepal. The selected three districts share 12.6% and 14.1% to total area and production in Nepal (MoALD, 2019). Within the selected districts, respondents from one local 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.
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2.2 Sampling design

Multistage random sampling technique was adopted for the selection of study area and sample respondents for collection of information required for the study. The rice grower of selected rural municipalities and municipalities were considered to be in sampling frame. The rice growing farms were divided into two categories i.e. mechanized and traditional rice farms. Mechanized farm referred to the rice farms that uses at least one or more of agricultural machines for at least one or more farm operations in tillage, transplanting, harvesting and threshing. The use of machines for at least tillage was considered mandatory. Traditional farms were referred as rice farm that used none of the agricultural machines for rice cultivation. The data were collected through structured and semi-structured questionnaires. Based on the population size, the sample size of the study was 494 respondents which constituted 220 respondents from traditional and 274 respondents from mechanized rice farms. The focused group discussion, key informant interviews and stakeholders analysis were performed during study. The sample size was determined as given to Table 1 using the following formula (Daniel and Cross, 2013):

Table 1: Sampling frame (N) and sample size (n)

District	Population size (No.)		Sample size (No.)	
	Mechanized	Traditional	Mechanized	Traditional
Jhapa	1895	334	91	75
Sunsari	1760	240	91	69
Bardiya	2007	354	92	76
Total	5662	928	274	220
Total Sample size: 494				

The sample size was determined using the following formula:

$$n = \left[\frac{[N\, z^2\, p\, (1-p)]}{[(N-1)d^2 + z^2\, p(1-p)]}\right]$$

(Daniel & Cross, 2013)

Where:

n = Sample size
N = Total population size/household
p = Estimated proportion of population included (50%)
d = Error limit (10%)

The field survey was conducted during December 15, 2018 – April 15,2019.

2.3 Analytical methods

Cost of cultivation: It is the sum of variable costs and fixed costs expressed on per hectare basis and was calculated as:

$$Total\ cost\ (NRs.) = Total\ fixed\ cost + Total\ variable\ cost$$

where,

Total variable cost = Sum of cost for -Human labor+ Animal labor + Machine hours + Seeds/seedlings + Manures/compost + Chemical fertilizers + Chemical/bio-pesticides + Irrigation + Interest on working capital (@7.5% interest rate/annum)

Total fixed cost (NRs. per hectare) = Rental value of land + Land tax + Depreciation of machineries + Repair and maintenance cost + Interest on fixed capital (@12% interest rate/annum)

2.4 Profit/loss analysis

Profit/loss is the difference between the gross return and total cost (NRs/ha) and was calculated from mechanized and traditional rice farms. Profit/loss was calculated as:

$$Net\ profit/loss\ (NRs) = Gross\ return - total\ cost$$

Where, Gross returns were obtained by multiplying the total product with its unit value and was calculated as,

$$Gross\ return\ (NRs.) = (price\ of\ main\ product * quantity + price\ of\ by\ product * quantity)$$

Profit/loss (NRs/ha): if value is positive indicates profit, and if negative loss.

2.5 Benefit Cost Ratio (BCR)

Benefit Cost Ratio (BCR) is assumed as a quick and one of the easiest methods for evaluating the economic performance of any farm (Dhakal et al., 2015). BCR compares the benefit per unit of cost. Thus, BCR was calculated by using the following formula:

$$BCR = \frac{Gross\ return(NRs.)}{Total\ cost\ (NRs.)}$$

3. Results and Discussion

3.1 Labor use

Labor use pattern in traditional farm in Jhapa and Sunsari was similar to the overall average pattern; transplanting accounting for the highest share to total human labor used and was followed by land preparation, harvesting and bundling. However, for traditional farm of Bardiya, land preparation shared the highest to total labor used and was followed by transplanting and harvesting and bundling. In mechanized rice farms, all the districts employed highest number of labor for transplanting. After transplanting, the number of labor required was highest for weed control and harvesting in all districts. Similarly, number of bullock labor use was highest for ploughing in all three districts in both mechanized and traditional rice farms. After ploughing, the highest number of labor use was recorded for transportation in Jhapa and Sunsari while puddling of rice field to make the field ready for transplantation used highest number of labor after ploughing in Bardiya district. On average the per hectare human labor used in traditional rice farming in Jhapa, Sunsari and Bardiya was 139.2, 143.4 and 142.1 man-days, respectively. Average machine hours use per hectare in mechanized rice farm was highest in Sunsari (15.7 hours) followed by Jhapa (13.4 hours) and Bardiya district (12.9 hours). Maximum machine hours was used in land preparation mechanized rice farms. After land preparation (tillage), puddling (land preparation for transplanting), threshing, winnowing and storage and harvesting and bundling used the highest hours of machine in Jhapa, Sunsari and Bardiya.

Table 2: Labor use pattern in sampled households

Farm operation	Jhapa (n=166)		Sunsari (n=160)		Bardiya (n=168)	
	Mechanized	Traditional	Mechanized	Traditional	Mechanized	Traditional
Human labor (man days)						
Land preparation	3.1	26.0	2.9	26.3	3.0	28.6
Fertilizers and compost transportation	3.0	7.6	3.6	7.6	2.8	8.4
Nursery Bed Preparation	1.2	6.3	1.2	7.9	1.3	7.4
Puddling of field for transplantation	3.9	10.7	3.8	10.8	3.6	10.8
Transplanting	22.3	30.2	23.9	29.7	20.0	24.8
weed control	19.7	20.2	18.1	20.9	18.0	21.3
Irrigation	1.6	1.7	1.6	1.6	1.6	1.4
Plant Protection	1.0	1.0	1.0	1.1	1.1	2.2
Harvesting, bundling	15.3	20.6	8.6	22.6	13.7	21.8
Threshing, Winnowing and storage	6.2	14.7	4.0	15.1	6.9	15.4
Subt-total-1	**77.3**	**139.2**	**68.7**	**143.4**	**72.0**	**142.1**
Bullock Labor (days)						
Ploughing	1.5	9.5	1.7	10.6	2.1	12.2
Puddling of field for transplantation	1.3	3.4	1.3	3.5	1.4	4.9
Transportation	1.3	5.4	1.0	4.8	1.1	3.7
Threshing, Winnowing and storage	0.7	4.0	0.8	3.8	0.6	2.2
Sub-total-2	**4.9**	**22.3**	**4.8**	**22.7**	**5.2**	**23.0**
Machine labor (hours)						
Land preparation	4.9	0.0	5.0	0.0	4.1	0.0
Fertilizers and compost transportation	0.8	0.0	1.0	0.0	0.9	0.0
Nursery Bed Preparation	0.5	0.0	0.6	0.0	0.5	0.0
Puddling of field for transplantation	1.9	0.0	2.0	0.0	1.6	0.0
Transplanting	0.3	0.0	0.6	0.0	0.4	0.0
weed control	0.2	0.0	0.8	0.0	0.5	0.0
Irrigation	1.1	0.0	1.4	0.0	0.5	0.0
Plant Protection	1.1	0.0	1.3	0.0	1.2	0.0
Harvesting, bundling	1.2	0.0	0.8	0.0	1.9	0.0
Threshing, Winnowing and storage	1.4	0.0	2.2	0.0	1.3	0.0
Sub-total-3	**13.4**	**0.0**	**15.7**	**0.0**	**12.9**	**0.0**

The average pooled labor utilization pattern in rice cultivation in both traditional and mechanized farms aggregate of 3 districts are presented in Table 3. The per hectare average human labor used by traditional farm was 141.6 man days which was almost double compared to mechanized farm (72.7 man days). Transplanting accounted for the highest use of man days (28.2) and was followed by land preparation (27.0), harvesting and bundling (21.7) of rice crop in traditional rice farm. In case of mechanized rice farm, the maximum number of human labor used was for transplanting/sowing of rice crop which shared 30.5% of total human labor used. After transplanting, weeding used maximum number of human labor (25.6%) out of total human labor used. Labor use pattern for all three districts for mechanized farm was similar to overall average pattern; transplanting sharing the highest and was followed by weeding. The highest share of labor was recorded in transplanting (19.9%) followed by land preparation (19.1%) in traditional rice farm.

The study showed remarkably low use of human labor for land preparation/tillage (3.0 man days) and threshing, winnowing and storage (5.7 man days) in mechanized rice farm compared to traditional farm which were 27 man days (for land preparation/tillage) and 15 man days (for threshing, winnowing and storage). This indicated the use of tillage and threshing machines for rice has lowered the use of human labor in rice farm. Similarly, number of bullock labor required was highest in ploughing/land preparation (10.8 bullock days) followed by transportation (4.6 bullock days) per hectare in traditional farm. Number of bullock labor required in traditional rice farm was more than 4 times higher than in mechanized rice farm. Similarly, per hectare average bullock use in mechanized and traditional rice farms was 5.0 and 22.6 days respectively.

Out of total bullock labor used, the highest share was constituted by ploughing which was 35.5% and 47.6% for mechanized and traditional farms respectively. After ploughing, bullock labor was mainly used for puddling (1.3 days) in case of mechanized farm while it was largely used for transportation (4.6 days) in traditional farm. For all three districts, land preparation had the highest share constituting almost a third of total machine hours used. The per hectare average machine hour used in study sites was 14.0 hours with land preparation, puddling and threshing, winnowing and storage accounting 33.4%, 13.1% and 11.9% respectively. The average human labor, bullock labor and machine labor in pooled rice farm was 107.2 man days, 13.8 days and 7 hours per hectare as shown in the Table 3:

Table 3: Share of human and bullock labors and machine hours to total labor requirement in rice cultivation (average of 3 study districts)

Farm operation	Pooled (n=494)		Mechanized (n=274)		Traditional (n=220)	
	Quantity	%	Quantity	%	Quantity	%
Human labor (man days)						
Land preparation	15	14.00	3	4.1	27	19.1
Fertilizers and compost transportation	5.5	5.13	3.1	4.3	7.9	5.6
Nursery Bed Preparation	4.2	3.92	1.2	1.7	7.2	5.1
Puddling of field for transplantation	7.3	6.81	3.8	5.2	10.8	7.6
Transplanting	25.2	23.52	22.2	30.5	28.2	19.9
weed control	19.7	18.39	18.6	25.6	20.8	14.7
Irrigation	1.6	1.49	1.6	2.2	1.6	1.1
Plant Protection	1.2	1.12	1	1.4	1.4	1
Harvesting, bundling	17.1	15.96	12.5	17.2	21.7	15.3
Threshing, Winnowing and storage	10.35	9.66	5.7	7.8	15	10.6
Subt-total-1	107.2	100.00	72.7	100	141.6	100
Bullock Labor (days)						
Ploughing	6.3	45.65	1.8	35.5	10.8	47.6
Puddling of field for transplantation	2.65	19.20	1.3	27.1	4	17.4
Transportation	2.85	20.65	1.1	22.8	4.6	20.4
Threshing, Winnowing and storage	2	14.49	0.7	14.6	3.3	14.6
Sub-total-2	13.8	100.00	5	100	22.6	100
Machine labor (hours)						
Land preparation	2.35	33.57	4.7	33.4	0	0
Fertilizers and compost transportation	0.45	6.43	0.9	6.3	0	0
Nursery Bed Preparation	0.25	3.57	0.5	3.7	0	0
Puddling of field for transplantation	0.9	12.86	1.8	13.1	0	0
Transplanting	0.2	2.86	0.4	3	0	0
weed control	0.25	3.57	0.5	3.6	0	0
Irrigation	0.5	7.14	1	7.2	0	0
Plant Protection	0.6	8.57	1.2	8.5	0	0
Harvesting, bundling	0.65	9.29	1.3	9.3	0	0
Threshing, Winnowing and storage	0.85	12.14	1.7	11.9	0	0
Sub-total-3	7.00	100.00	14	100	0	0

The study showed the significant differences labor use in performing various farm operations except irrigation in mechanized and traditional rice farms. The labor used in mechanized rice farm was significantly lower than in traditional rice farm at 5% and 1% level of significance (Table 4). Labor use mean differences were maximum in land preparation followed by post-harvest operations (threshing, winnowing and storage of the rice grains). This indicated that the use of farm machines for rice cultivation would significantly reduce the use of the human labor thereby removing drudgery and addressing the labor shortage issues while doing various farm operation in rice cultivation. Similarly, there was significant difference in use of bullock labor in mechanized and traditional rice farms. The mechanized rice farm was using less number of bullock labor (5.0 bullock days) than traditional rice farms (22.6 days) and the difference was significant at 1% level. This also clearly indicated that the mechanized rice farms displaces the bullock use for rice cultivation.

Table 4: Variation in average labor use (man days) status in mechanized and traditional rice farms in Terai

Description	Pooled (n=494)		Mechanized (n=274)		Traditional (n=220)		Mean difference	t- value
	Mean	Std Dev	Mean	Std Dev	Mean	Std. Dev		
Land preparation	15.00	13.59	3.0	0.72	27.0	9.76	-24.0**	-40.497
Fertilizers and compost transportation	5.50	3.16	3.1	1.63	7.9	2.56	-4.8**	-25.036
Nursery Bed Preparation	4.20	3.29	1.2	.55	7.2	2.10	-6.0**	-44.718
Puddling of field for transplantation	7.30	4.33	3.8	1.17	10.8	3.63	-7.0**	-30.046
Transplanting	25.20	8.42	22.2	9.84	28.2	4.22	-6.0**	-8.635
weed control	19.70	7.97	18.6	10.38	20.8	2.52	-2.2*	-2.994
Irrigation	1.60	.77	1.6	.78	1.6	.76	0.0	0.198
Plant Protection	1.20	.62	1.0	.21	1.4	.85	-0.4**	-7.470
Harvesting, bundling	17.10	8.50	12.5	9.13	21.7	3.49	-9.2**	-13.99
Threshing, Winnowing and storage	10.35	4.98	5.7	2.27	15.0	1.22	-9.3**	-54.571
Total	**107.2**	**15.05**	**72.7**	**20.07**	**141.6**	**12.27**	**-68.9****	**-44.58**
Bullock labor used	13.8	3.11	5.0	2.05	22.6	3.01	-17.3**	-77.389
Machine labor used	7.0	14.0	14	6.44	00	00		

* and ** indicate significant at 5% and 1% level of significance

3.2 Cost and returns

The average cost and return analysis by mechanized and traditional rice farms is presented in Tables 5 and 6. The tables contain comparative performance of mechanized and traditional rice farms in Nepal Terai with respect to cost, return and productivity.

3.2.1 Cost of production of rice in mechanized and traditional farms (NRs/ha)

The cost of production of rice in mechanized and traditional rice farms is presented in the Table 5. The variable cost of cultivation in mechanized and traditional rice farms was NRs. 61,726.4 and NRs. 82,093.2 per hectare, respectively indicating lower cost incurred in mechanized rice farms. Mechanized rice farms used 72.7 man days per hectare while 141.6 man days per hectare by traditional rice farms. Moreover, share of human labor to total cost of production in traditional rice farms was 59.5%. and it was 35.6% in case of mechanized rice farms while other components of variable cost had similar share to the total cost of production in both the farms. Study revealed a huge difference in number of human labor used in mechanized and traditional rice farms implying that human labor cost can considerably be reduced through use of agricultural machines.

Table 5: Average cost of production of rice in mechanized and traditional farms (NRs/ha)

Farm operations	Unit	Mechanized (n=274)			Traditional (n=220)			Total (n=494)		
		Quantity	Total cost	%	Quantity	Total cost	%	Quantity	Total cost	%
Variable cost										
Human labor	Man days	72.7	30410.4	35.6	141.6	57163.9	59.5	107.2	43787.1	48.3
Animal labor	days	5.0	1576.0	1.8	22.6	7119.0	7.4	13.8	4347.5	4.8
Machine labor	Hour	14.0	13713.0	16.1				7.0	6856.5	7.6
Total labor			45699.4	53.5		64282.9	67.0		54991.2	60.6
Seeds/seedlings	Kg	61.7	3074.3	3.6	65.0	3239.5	3.4	63.3	3156.9	3.5
Manures and compost	Kg	1628.1	1356.8	1.6	1336.4	1903.7	2.0	1482.3	1630.2	1.8
Chemical fertilizers	Kg									
Urea	Kg	117.2	1980.1	2.3	117.7	2098.4	2.2	117.4	2039.3	2.2
DAP	Kg	58.4	2698.1	3.2	57.6	2745.6	2.9	58.0	2721.8	3.0
Potash	Kg	30.2	1026.8	1.2	33.2	1147.6	1.2	31.7	1087.2	1.2
Chemical and bio pesticides	NRs.		1391.3	1.6		1042.4	1.1		1216.89	1.3
Irrigation	NRs.		461.4	0.5		483.6	0.5		472.48	0.5
Interest on working capital			4038.2	4.7		5149.5	5.4		4593.84	5.1
Total Variable cost	NRs.		61726.4	72.2		82093.2	85.5		71909.8	79.3
Rental value of land (per ha)	NRs.		8868.7	10.4		6625.6	6.9		7747.12	8.5
Land tax	NRs.		412.7	0.5		407.9	0.4		410.32	0.5
Depreciation	NRs.		3734.3	4.4		646.5	0.7		2190.38	2.4
Repair and maintenance	NRs.		4442.0	5.2		612.8	0.6		2527.40	2.8
Interest on fixed capital	NRs.		2182.2	2.6		1036.6	1.1		1609.40	1.8
Total fixed cost	**NRs.**		**19,639.9**	**23.0**		**9,329.3**	**9.7**		14,484.6	16.0
Sub Total cost	**NRs.**		**81,366.3**	**95.2**		**91,422.5**	**95.2**		86,394.4	95.2
Managerial cost 5%			4068.3	4.8		4571.1	4.8		4319.7	4.8
Total cost			**85,434.6**	**100**		**95,993.6**	100		90,714.1	100

Note: 1 USD =117.50 NRs. (As of 24th October 2020)

The cost incurred in both types of farms (mechanized and traditional) was statistically tested to make inference, whether the significant difference among variable cost items between two type of farms prevails. The study showed that there was significant difference in mean values at 1% level of significance for labor cost, plant protection cost, other variable costs and fixed costs as shown in the Table 6. This showed that the labor cost in mechanized farm was lower than the labor cost incurred in traditional farms, and the mean difference was NRs. 26,753.5 which was significant. This showed the labor cost for mechanized rice farm significantly lower than traditional. Similarly, there was significant difference in plant protection and irrigation costs. Mechanized rice farm incurred more cost on plant protection while irrigation cost was higher in traditional farm. The difference in seed cost and fertilizer costs were NRs. 165.2 and NRs. 286.6, respectively and were not significant. It means both type of rice farms were using seed and fertilizer at similar rates. The farmers from traditional farm category were spending more cost for compost and FYM and the difference with mechanized farm was significant. There was significant difference in bullock cost per hectare between mechanized and traditional rice farms. The mechanized rice farms had incurred less cost for bullock labor than traditional rice farms, which indicated that use of machines had displaced the bullock labor in study sites. The variable cost saved in mechanized rice farm in comparison to traditional rice farm was NRs. 20,366.8 per hectare (24.80%).

Table 6: Variation in cost of rice production between mechanized and traditional rice farms (NRs./ha)

Description	Overall (n=494)	Mechanized (n=274)		Traditional (n=220)		Mean difference	t- value
		Mean	Std Dev	Mean	Std. Dev		
Seed Cost	3156.9 (976.7)	3074.3	658.5	3239.5	782.9	-165.2 (NS)	0.117
Labor cost (Human)	43787.1 (16987.1)	30410.4	15459.9	57163.9	16368.0	-26753.5**	13.321
Plant protection cost	1216.8 (1123.1)	1391.3	1158.0	1042.4	813.6	348.9**	-6.074
Irrigation cost	472.5 (345.55)	461.4	258.3	483.6	193.4	-22.2*	-1.02
Bullock cost	4347.5 (878.65)	1576	716.12	7119	1209.29	-5543**	-63.82
Compost and manure cost	1630.2 (2111.79)	1356.8	1836.8	1903.7	2320.36	-546.9**	3.007
Fertilizer cost	5848.3 (1276.3)	5705	1482.2	5991.6	1318.9	-286.6 (NS)	0.073
Variable cost	71909.8 (9087.7)	61726.4	10608.3	82093.2	8112.0	-20366.8**	19.96
Fixed cost	14484.6 (2154.8)	19639.9	2833.1	9329.3	1857.4	10310.6**	-46.55

NS= Non significant

*= Significant at 5%, **=Significant at 1 % level of significance

Note: 1 USD =117.50 NRs. (As of 24th October 2020)

3.3 Yield and returns

The results of yield and returns in rice production in mechanized and traditional rice farms is presented in Table 7. The yield of main crop was higher mechanized rice farms (4.29 t/ha) compared to traditional farms (3.89 t/ha). The higher yield in mechanized category was mainly due to adoption of mechanization so that farmers could do farm operation in rice farming in time and with more efficiency. Higher yield could also be due to adoption of hybrid rice variety by farmers of mechanized rice farm. Per hectare gross and net returns in mechanized and the traditional rice farms were NRs 112,711.0 and 27,218.8, and NRs. 102,064.9 and 6,071.3 respectively. The returns per rupee invested was higher in mechanized rice farm (NRs.1.32) compared to traditional rice farm (NRs. 1.06). The higher income and lower average variable costs in mechanized rice farms was a clear indication that adoption of mechanization in rice cultivation increases yield and farm income through timely operation, removal of drudgery and use of production input more effectively and efficiently.

The difference in mean value of gross income, net income, B/C ratio, yield and household production of rice obtained from mechanized and traditional rice farm in Jhapa, Sunsari and Bardiya districts were tested using independent samples t-test. The result depicted significant difference all the parameters in all the districts at 1% level of significance (Table 7). This indicated that the adoption of agricultural tools and machines in rice farming led to significantly higher yield, net income, B/C ratio, profit and household rice production for mechanized farm compared to traditional rice farm. Thus, it is advised to the concerned authority to execute program and policies to promote agricultural mechanization in rice cultivation in Nepal.

Table 7: Comparison of average cost and returns of mechanized and traditional rice farms (Main product)

Particulars	**Overall**		**Farm type**				**Mean difference (NRs.)**	**t-value**
			Mechanized (n=274)		**Traditional (n=220)**			
	NRs.	**Std dev**	**NRs.**	**Std dev**	**NRs.**	**Std dev**		
Jhapa (N=166, Mechanized = 91, Traditional= 75)								
Gross income (NRs./ha)	107609.1	14601.7	115350.4	14867.5	99867.9	11566.9	12413.8**	5.444
Net Profit (NRs/ha)	14697.4	18658.7	28598.4	16924.4	796.4	14433.6	27802**	8.043
B/C Ratio (per ha)	1.17	0.22	1.33	0.22	1.01	0.151	0.32**	7.893
Yield (Kg/ha)	4103.5	2469.3	4373.62	2818.8	3833.3	1693.1	540.32**	3.734
Production in HH (Kg/HH)	4724.03	8005.8	6102.6	10271.1	3051.2	3071.2	3051.4**	2.482
Sunsari (N=160, Mechanized = 91, Traditional= 69)								
Gross income (NRs./ha)	105294.3	8228.2	109410.9	9425.2	101177.8	4745.4	4958.1**	4.532
Net Profit (NRs/ha)	16963.8	14421.7	25089.9	14327.3	8837.8	10393.5	16252.1**	6.66
B/C Ratio (per ha)	1.20	0.197	1.30	0.20	1.10	0.12	0.2**	6.60
Yield (Kg/ha)	4062.5	2224.6	4175.8	360.3	3949.3	174.5	226.5**	4.80
Production in HH (Kg/HH)	4078.1	314.9	3887.6	2557.6	2937.7	1546.9	949.9**	2.72
Bardiya (N=167, Mechanized= 91, Traditional= 76)								
Gross income (NRs./ha)	109271.8	14601.7	113395.0	9173.3	105148.5	7322.6	7755.9**	6.20
Net Profit (NRs/ha)	17594.9	18658.7	27418.8	13476.5	7771.0	11736.5	19647.8**	9.15
B/C Ratio (per ha)	1.20	0.22	1.32	0.191	1.08	0.124	0.24**	8.94
Yield (Kg/ha)	4110.4	2469.3	4326.08	301.6	3894.7	294.6	431.38**	9.11
Production in HH (Kg/HH)	4385.6	3447.8	5174.9	3853.8	3440.6	2613.1	1734.3**	3.33

*= Significant at 5%, **=Significant at 1 % level of significance

Note: 1 USD =117.50 NRs. (As of 24th October 2020)

The similar result was obtained when overall performance of mechanized and traditional rice farms with respect to yield, income and B/C ratio was compared. The study showed that net income, gross income, B/C ratio, yield and household production was significantly higher for mechanized rice farms compared to traditional rice farm as shown is Table 8.

Table 8: Variation in yield and returns between mechanized and traditional rice farms

Particulars	Overall (n=494)	Farm type		Mean difference	t-value
		Mechanized (n=274)	Traditional (n=220)		
Gross income (NRs./ha)	107388.0 (11280.0)	112711.1 (11745.3)	102064.9 (8670.0)	8361.9**	8.84
Net Profit (NRs/ha)	16673.9 (16423.9)	27276.5 (15015.2)	6071.3 (12621.5)	21205.2**	13.65
B/C Ratio (per ha)	1.19 (0.210)	1.32 (0.20)	1.06 (0.136)	0.26**	13.44
Yield (Kg/ha)	4092.1 (1464.7)	4291.84 (1643.1)	3892.4 (1095.1)	399.44**	5.33
Production in HH (Kg/HH)	4212.39 (5229.7)	5052.7533 (6531.3)	3165.7693 (2531.5)	1886.984**	4.04

*= Significant at 5%, **=Significant at 1 % level of significance
Note: 1 USD =117.50 NRs. (As of 24th October 2020)

4. Conclusion

The objective of this study was to assess the cost, return and yield of mechanized and traditional rice farms. The study was conducted in Jhapa, Sunsari and Bardiya districts of Nepal. The total sample size for the study was 274 mechanized and 220 traditional rice farms, which was selected using multi-stage random sampling. The study concluded that the total labor required for mechanized rice farm was significantly lower than traditional rice farm except for irrigation. Number of bullock labor required in traditional rice farm was more than 4 times than in mechanized rice farm. The use of machine was higher for land preparation in mechanized rice farm. The study revealed that the use of farm machines for rice cultivation significantly reduced the use of human labor thereby removing drudgery and addressing the labor shortage issues while doing various farm operations in rice cultivation. Share of human labor to total cost of production in traditional rice farms was higher than in mechanized rice farms.

There was significant difference in number of human labor used in mechanized and traditional rice farm implying that human labor cost can considerably be reduced through use of agricultural machines. The variable cost saved in mechanized rice farm in comparison to traditional rice farm was NRs. 20,366.8 per hectare, which was 24.80%. The rice yield was higher in mechanized farms (4.29 t/ha) in comparison to traditional farms (3.89 t/ha). Returns per rupee invested was higher in mechanized rice farms (NRs. 1.32) compared to traditional rice farms (NRs. 1.06). The use of mechanization was mainly for tillage, harvesting and threshing which are most labor consuming and tedious operations in rice farming in Nepal. The study clearly indicated that adoption of mechanization in rice cultivation increases yield and farm income through timely operation, removal of drudgery and use of production input more effectively and efficiently. Thus, it is advised to the concerned authority to execute program and policies to promote agricultural mechanization in rice cultivation in Nepal.

Authors' Contributions

P. Acharya conducted research and wrote the paper. P.P. Regmi, D. Gauchan, D.B. KC and G.B. KC revised and provided the critical feedback to finalize the paper.

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