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Resource use efficiency of mechanized and traditional rice farms in Nepal: A comparative analysis

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***Abstract*— *This paper has compared the resource use efficiency in rice production among mechanized and traditional farmers in Tarai districts (Jhapa, Sunsari and Bardiya) of Nepal in 2018/19. Data were collected from 494 farmers (274 mechanized and 220 traditional) using multistage random sampling. Production function analysis (Cob-Douglas production function) was used to obtain the marginal value productivity of inputs and to examine the resource use efficiency in crop production in mechanized and traditional rice farms. Study showed that machinery cost was highest and significant to the total income from rice in mechanized rice farm, whereas fertilizer cost accounted the highest in traditional rice farm. Increase in human labor was found to decrease the income from crop in mechanized rice farm. Effect of manures, fertilizers and bio and chemical pesticides was positive and significant in both type of farms. The effect of irrigation cost was significant in mechanized farm and it was non-significant for traditional farm. There was decreasing returns to scale in all the farms. Production resources in the study area were found not to be efficiently utilized to optimum economic advantage for both mechanized and traditional rice farmers, respectively. Return to scale was found to be 0.695 and 0.488 for mechanized and traditional rice farm which revealed that inputs used in rice production were ineffectively utilized in which manures, chemical fertilizers, machineries, bio- and chemical pesticides and irrigation resource were under used and human labor, seed and animal labor over used. This situation of underutilization of these resources should be overcome by increasing farmers' access to these inputs and encouraging them to use in higher quantity to realize higher return. Assurance of quality and timely supply of fertilizers, plant protection materials and investment on irrigation infrastructure should be done by government authority to increase in efficiency of resources used by farmers. Moreover, technology packages for adequate and timely application of these inputs should be delivered to the farmers to maximize returns through increased resource use efficiency. Relevant policies should be formulated to encourage the creation of alterative employment opportunities to absorb the excess labor used in rice production. Based on the result obtained it can be concluded that mechanized rice production is more efficient in resource utilization and subsequently more profitable than traditional farming.*

***Keywords*— Mechanization, Resource Use Efficiency, Returns to Scale, Efficiency.**

I. INTRODUCTION

Agriculture sector is considered as an important economic sector to increase income, alleviate poverty and also enhance the living standard of Nepali people (Gauchan and Shrestha, 2017). Agriculture contributes 26.98% of country's GDP (MoALD, 2019) and engages 60.4% of its labor force (NPC, 2020). However, the productivity of agriculture in Nepal is placed the lowest in South Asian countries (FAO, 2019). The indicators, like 21% of population without having access to adequate food and 18.7% of population under absolute poverty line, indicate food insecurity and poverty are major issues of the Nation in the present times.

Rice is placed at the first rank among cereal crops in terms of its area, production and contribution to GDP, 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 and ASoN, 2017).Currently, from the area of 1.49 million hectares of land, 5.61 million metric tons of rough rice is produced in Nepal. Terai region of the country has highest shares with more than 70% in term of area and production in Nepal (MoALD, 2019). However, the average growth rate in area and production of rice is only about 0.35% and 1%, respectively per year (Regmi, 2017).

Rice is labor intensive crop and thus requires large number of labors during various farm operations (Bhandari *et al*., 2015 and Dhital, 2017). The rice productivity is greatly affected by labor scarcity during crop establishment (Liu et al, 2017). For the successful crop production, the timeliness of farm operations is important and use of improved implements and machineries is more important for undertaking the farm operation in time. In this context, farm mechanization can help address shortage of labor, ease drudgery, enhance productivity and the timeliness of agricultural activities and promote efficiency in resource use (ESCAP, 2018).

The number of of factors of production and their time of applications influence the agricultural production. Farmers adopting new and modern agricultural technology are found to utilize production inputs more efficiently than non-adopters (Idi, 2004). If the resources are utilized efficiently, the output and income of farmers can be increased at the existing technology, and about 28% increase in output of rice is obtained by adoption of the technology and best practices (Ajao, 2005). As Nepal is currently net importer of rice and thus investigation of the status of resource use in rice farms to determine the adjustments needed to increase the output is the indispensable approach at the moment. In order to feed the growing human population, increase in agricultural production by increasing resources use efficiencies through farm mechanization is required. Efficient use of resources and adoption of new technologies are the major emphases to be given to increase agricultural production thereby leading the country to be self-sufficient in rice production. Farm mechanization could be the option for Nepali rice growers to increase the use of machineries in rice cultivation and increase the production by efficient use of resources. For obtaining maximum production from any agricultural commodity, resources must be available and available resources must be used efficiently, and for this purpose, one must have knowledge about whose quantity rate should be increased or decreased (Alimi, 2000). The major factors affecting the technical efficiency of rice production include seed, fertilizer, labor as well as irrigation (Hasnian and Hossain, 2015). For increasing the production of rice, the use of improved farm mechanization and input is the best way (Nargis and Lee, 2013).

Experiences with quantifying the impact of mechanization on agricultural production efficiency in Nepal are very limited. There are no studies till date on comparative analysis of the agricultural production efficiency of rice between mechanized and traditional farms. A study of resource use efficiency on mechanized and traditional rice farms can explain the marginal value productivity of inputs between two categories of farms and justify the investment demands. Thus, the current study examines the resource use efficiency of mechanized and traditional rice farms which would ultimately help Nepali rice growers to compare the efficiencies of resources between two types of rice farms and make appropriate adjustment to existing resources use patterns for increasing the production on time.

II. MATERIALS AND METHODS

Study area: The study was conducted in Jhapa and Sunsari districts of province 1 and Bardiya districts of Lumbini province. The districts were among the most potential districts in rice production in Nepal. The three districts share 12.6% and 14.1% of total national area and production, respectively in Nepal (MoALD, 2019). 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 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.

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 growing farms were divided into two categories, i.e. Mechanized and Traditional rice farms. Mechanized farm referred to the rice farm that uses at least one or more of agricultural machines for at least one or more farm operation in tillage, transplanting, intercultural operation, harvesting and threshing. The rice growers of the selected rural municipalities and municipalities were considered to be in sampling frame. The data were collected through structured and semi-structured questionnaires. Based on the population size, the sample size of the study was 494, which was constituted of 274 from mechanized rice farms and 220 respondents from traditional (Table 1). The focused group discussion, key informants interview and stakeholders analysis were performed during study. The sample size was determined using the following formula (Daniel and Cross, 2013) and was also verified by using Raosoft software.

Table 1: Sampling frame

District	Population size		Sample size	
	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 and Cross, 2013)

Where:

n = Sample size

N = Total population size/household

p = Estimated proportion of population included

d = Error limit (10%)

The field survey was conducted during 2018/19

Analytical methods: The production function approach was used to find out the productivity of resources used in rice cultivation. For this purpose, Cobb Douglas production function model as described by Gujarati (2009) was adopted to estimate the resource use efficiency of various inputs at different farm categories, i.e. mechanized and traditional rice farms. The present study has compared the marginal value products of the inputs with their respective per unit acquisition cost to arrive at the use efficiency of such inputs. If the marginal value product of certain resources was lesser or greater than its acquisition cost, the input was considered to be over-utilized or under-utilized, respectively. To determine the contribution of different inputs as well as for the estimation of the efficiency of variable production inputs in rice production system in mechanized and traditional rice farms, the general form of Cobb-Douglas production function used was as follow:

$$Y = a\, X_1^{b}{}_1\, X_2^{b}{}_2 X_3^{b}{}_3 X_4^{b}{}_4 X_5^{b}{}_5 X_6^{b}{}_6{}^{b}{}_7 X_7^{b}{}_8 X_8$$

The dependent and explanatory variables were transformed to natural logarithm.

$$LnY = \ln a + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7\ln X_7 + b_8\ln X_8 + vi + ui$$

Where,

Ln = Natural logarithm

Y = Total income from rice cultivation (NRs./ha)

X_1 = Seed cost (NRs./ha)

X_2 = Manures/compost cost (NRs/ha)

X_3 = Fertilizer cost (NRs./ha)

X_4 = Chemical/bio pesticides cost (NRs/ha)

X_5 = Irrigation cost (NRs/ha)

X_6 = Machine hours cost (NRs/ha)

X_7 = Human labor cost (NRs./ha)

X_8 = Animal power cost (NRs./ha)

Vi = Error term measuring errors not under the control of farmers

Ui = Error term measuring errors under the control of farmers.

$b_{1,}\ b_{2...}b_8$ = Coefficients to be estimated

The resource use efficiency ratio (r), absolute value of percentage change in MVP (D) and return to scale (RTS) was estimated by using the following formula, as coined by Sapkota *et al*. (2018). Enlist this literature in Reference list.

r = MVP/MFC

Where, r= efficiency ratio, MVP = Marginal Value Product of variable input, MFC= Marginal Factor Cost

The Marginal Value Product was estimated using the following formula:

$$MVPi = bi\frac{y}{xi}$$

Where, b_i = estimated regression coefficients, y = Geometric mean of total income from rice cultivation, x_i= Geometric mean of i^{th} input.

Decision criteria:

If, r = 1 indicates the efficient use of the resource

If, r> 1 indicates underuse of the resource

If, r< 1 indicates overuse of the resource

Similarly, the absolute value of percentage change in MVP of each resource was estimated as

$$D = \left(1 - \frac{MFC}{MVP}\right) * 100$$

or

$$D = \left(1 - \frac{1}{r}\right) * 100$$

Where, D= Absolute value of percentage change in MVP of each resource.

The returns to scale (RTS) was calculated as follows:

RTS =Σ bi, Sum of bi from the cobb-Douglas production function gives the value of return to scale.

Where, bi = coefficient of i^{th} explanatory variables obtained from OLS regression of Cobb-Douglas production function

Decision rule:

If, RTS < 1: Decreasing return to scale

If, RTS = 1: Constant return to scale

If, RTS > 1: Increasing return to scale

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

III. RESULTS AND DISCUSSION

Land holding status in study sites

The study showed that the 45.5% of respondents under traditional rice farm categories had land holding of less than 0.66 ha (20 *kattha*) whereas 30.3% of respondents under mechanized rice farms had land holding of less than 0.66 ha. The land holding size of more than 1.33 ha was higher in mechanized farm (21.5%) as compared to traditional rice farm category (17.2%). The average land holding size of respondents in both type of farm was higher in Bardiya. The difference in average land holding in mechanized and traditional rice farms in all districts under study were significantly different at 5% and 1% level of significance. The details of land holding status in study areas is presented in the Table below:

Table 2: Land holding range

Land holding	Traditional	Mechanized	Total
< 0.66 ha	100 (45.5)	83 (30.3)	183 (37.0)
0.66-1.33 ha	82 (37.3)	132 (48.2)	214 (43.3)
>1.33 ha	38(17.2)	59 (21.5)	97(19.7)
Total	220 (100)	274 (100)	494 (100)

Figures in parenthesis indicate percentage

The average land holding was 0.83 ha/HH and 1.06 ha/HH in traditional and mechanized rice farm. The average rice cropped area was 0.77 and 1.02 ha/HH for traditional and mechanized rice farms. The study indicated that mean difference in rice area/HH between traditional and mechanized rice farms was significant at 5% level of significance. The mean differences in rice areas in both type of farm categories in all three districts was also significant at 5% and 1% level of significance as shown in the Table. The respondents from mechanized rice farm category in Bardiya district had highest rice area/HH (1.16 ha/HH) whereas in respondents from traditional rice farms of Jhapa district had highest land area under rice crop (0.78ha/HH) as shown in the Table.

Table 3: Land holding status

Districts	Average land holding (ha/HH)			Average rice area (ha/HH)			t-test	
							Mean difference (rice area)	t-value
	Overall	TF	MF	Overall	TF	MF		
Jhapa	0.92	0.82	1.02	0.88	0.78	0.98	-0.20*	-2.514
Sunsari	0.87	0.77	0.97	0.83	0.75	0.91	-0.16*	-2.413
Bardiya	1.045	0.89	1.20	0.965	0.77	1.16	-0.39**	-2.566
Total	**0.95**	**0.83**	**1.06**	**0.89**	**0.77**	**1.02**	**-0.25***	**-2.443**

TF = Traditional rice farm, MF=Mechanized rice farm

Adoption of variety

The majority of respondents in both the mechanized and traditional rice farms were found to adopt improved varieties. Percentage of the respondents in mechanized and traditional rice farm adopting the improved varieties of rice were 70.90% and 63.64% respectively. The adoption of hybrid varieties was higher in mechanized rice farm (18.25%) in comparison to traditional rice farm (12.23%). The average coverage of improved varieties to total rice area in mechanized and traditional rice farms were 69.14% and 70.61% respectively. This indicates about 70% area coverage by improved varieties in both the mechanized and traditional farm. The area covered by hybrid varieties in mechanized rice farm was 19.79 % of the total rice area cropped whereas it was 12.23% in traditional rice farm. The adoption of local varieties were higher in traditional rice farm (25.0%) as compared to mechanized rice farm (9.85%). The majority of varieties adopted in both type of farms were old varieties like Makawanpur-1 (Bardiya), Radha-4 (Jhapa, Sunsari, Bardiya), Ram Dhan (Jhapa, Sunsari), Sabitri (Jhapa, Sunsari Bardiya), Hardinath-1 (Jhapa, Sunsari, Bardiya), Sarju-52 (Bardiya), Ranjit (Jhapa and Sunsari), Sona Masuli (Sunsari), Sawa Masuli (Jhapa and Sunsari). However, in few cases new and climate resilient varieties like Cheharang sub-1(Bardiya), Sworna Sub-1(Jhapa, Sunsari, Bardiya), Sambha Masuli Sub-1(Jhapa, Sunsari), Bahuguni-1and Bahuguni-2 (Jhapa, Sunsari) etc were found to be adopted by respondent farmers. Hybrid varieties adopted were mainly registered and imported from India. Gorakhnath-509 (Bardiya, Sunsari), Garima (Jhapa, Sunsari), US-312 (Sunsari) were popular hybrid varieties adopted by the farmers in both mechanized and traditional rice farms. Lalka basmati (Jhapa, Sunsari), *Kariya kamad* (Jhapa, Sunsari), Tilki (Bardiya), *Anadi* (Bardiya) etc varieties were among the local varieties being adopted by the respondents in study sites. The area coverage under local varieties of rice in mechanized and traditional rice farm was 11.04 % and 17.14 % respectively. More specifically, the highest percentage of respondent farmers from mechanized farm category of Bardiya district (73.91%) had adopted improved rice varieties followed by Sunsari (71.73%) and Jhapa (70.33%). Similarly, highest percentage of respondents in Sunsari (21.98%) were adopting hybrid rice varieties followed by Jhapa (16.48%) and Bardiya (16.30%) in mechanized farm category. The result was similar for traditional rice farm with regard to adoption of hybrid rice varieties in traditional rice farm with highest percentage of household adopting hybrid varieties in Sunsari (13.04%) followed by Jhapa (10.67%) and Bardiya (10.53%).

Table 4: Adoption of rice varieties in study sites

District	Farm Category	Descriptions	Improved	Hybrid	Local	Total
Jhapa (N=166)	Mechanized (N=91)	Household No	64 (70.33)	15 (16.48)	12 (13.19)	91 (100)
		Area.	60.17 (67.33)	18.30 (20.48)	10.90 (12.20)	89.37 (100)
	Traditional (N=75)	Household No.	50 (66.67)	8 (10.67)	17 (22.67)	75 (100)
		Area	39.51 (67.42)	7.66 (13.07)	11.43 (19.51)	58.60 (100)
Sunsari (N=160)	Mechanized (N=91)	Household No.	65 (71.43)	20 (21.98)	6 (6.59)	91 (100)
		Area	53.14 (64.17)	24.21 (29.24)	5.46 (6.59)	82.81 (100)
	Traditional (N=69)	Household No.	41 (59.42)	9 (13.04)	19 (27.54)	69 (100)
		Area	36.54 (70.94)	7.42 (14.40)	7.55 (14.66)	51.51 (100)
Bardiya (N=168)	Mechanized (N=92)	Household No.	68 (73.91)	15 (16.30)	9 (9.78)	92 (100)
		Area	79.76 (74.50)	12.75 (11.91)	14.55 (13.59)	107.06 (100)
	Traditional (N=76)	Household No.	49 (64.47)	8 (10.53)	19 (25.0)	76 (100)
		Area	49.50 (73.16)	6.67 (9.86)	11.49 (16.98)	67.66 (100)
Total (N=494)	Mechanized (N=274)	Household No.	197 (71.90)	50 (18.25)	27 (9.85)	274 (100)
		Area	193.07 (69.14)	55.26 (19.79)	30.91 (11.07)	279.24 (100)

District	Farm Category	Descriptions	Improved	Hybrid	Local	Total
	Traditional (N=220)	Household No.	140 (63.64)	25 (11.36)	55 (25.00)	220 (100)
		Area	125.55 (70.62)	21.75 (21.23)	30.47 (17.14)	177.77 (100)

Figures in parenthesis indicate percentage

labor use status in mechanized and traditional rice farms

The study showed the significant differences in status of labor use in performing various farm operations except irrigation in mechanized and traditional rice farms. The labor use in mechanized rice farm was significantly lower than in traditional rice farm at 5% and 1% level of significance. The mean differences was maximum in labor use for land preparation followed by threshing, winnowing and storage of the rice grain. This indicated that the use of farm machines for rice cultivation would significantly displace 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 farm. The mechanized rice farm was using lower number of bullock power (5.0 days) than traditional rice farm (22.6 days) and the difference was significant at 1% level of significance. This also clearly indicated that the mechanized rice farm displaces the bullock use for rice cultivation.

Table 5: Mean differences in labor use status in mechanized and traditional rice farms

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	25.2	8.42	22.2	9.84	28.2	4.22	-6.0**	-8.635
weed control	19.7	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	17.1	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

Description	Pooled (N=494)		Mechanized (N=274)		Traditional (N=220)		Mean difference	t- value
	Mean	Std Dev	Mean	Std Dev	Mean	Std. Dev		
Machine labor used	7.0	14.0	14	6.44	00	00		

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

Estimation of elasticity, MVP, returns to scale and efficiency ratio in study areas

Overall pool results including farms from all three sampled districts showed positive and significant impact of manures, fertilizers and plant protection measures to return. Table 6 presents estimation of elasticity in mechanized and traditional rice farms in study areas. The impacts of irrigation and machines were significant and positive, seed was positive but non- significant to the return in case of mechanized farms. This indicated that additional use of seed would not be adding more output. This could be because farmers were using seed rate for rice cultivation more than recommended, as a result of which additional use of seed would not necessarily increase the output. In mechanized farms, 1% increase in machine cost would increase the income by 0.379%. Fertilizers cost was second to machine cost to contribute in total income in mechanized rice farms. Human labor showed negative and significant impact and animal power showed negative, but non-significant impact to the return in case of mechanized farms. That means additional supply of labor in rice production system would decrease the income from the rice crop. Seed and animal power showed negative impact on return, while the impact on return was negative and significant for human labor in case of traditional farms. In traditional rice farms, fertilizer was found to be having the highest impact on return .

Table 6: Estimation of elasticity in mechanized and traditional rice farms in study areas

Variables	Mechanized				Traditional			
	Coefficients	Std. Error	t-value	Sig.	Coefficients	Std. Error	t-value	Sig.
Log seed cost	0.016	0.020	.219	0.827	0.017	0.018	-1.921	0.056
Log manures	0.152∗	0.012	2.607	0.010	0.154∗∗	0.011	9.727	0.000
Log fertilizers	0.307∗∗	0.035	5.825	0.000	0.247∗∗	0.024	5.839	0.000
Log bio/ chemical pesticides	0.095∗	0.010	2.393	0.017	0.096∗∗	0.009	6.687	0.000
Log irrigation cost	0.066∗	0.015	2.181	0.030	0.134	0.017	1.418	0.157
Log machine cost	0.379∗∗	0.020	6.281	0.000	-0.201∗∗	0.008	-3.588	0.000
Log human labor cost	-0.299∗∗	0.007	-3.550	0.000	0.041	0.012	-.486	0.628
Log animal power cost	-0.021	0.016	-1.277	0.203	4.195	0.140	29.961	0.000
Constant	3.616∗∗	0.212	17.074	0.000	-0.201∗∗	0.008	-3.588	0.000
F-Value	31.423				50.96			
Prob>F	0.000				0.000			
R^2	0.700				0.757			
Adjusted R^2	0.491				0.573			
Returns to scale	0.695				0.488			

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

The estimation of MVP, efficiency ratio and returns to scale of mechanized and traditional rice farms in the study areas is presented in Table 7. Seed was over-utilized, human labor and animal power were grossly over utilized in mechanized farms, while for traditional farms, these three inputs were grossly over utilized elucidating need of decreasing cost on these resources for return maximization. Manures, fertilizers, plant protection measures, irrigation and machines were underutilized depicting need of increasing cost on these inputs to maximize return. Percent adjustment required for irrigation and plant protection measures were almost similar in both categories of farms, while for mechanized farms, manures needed to be increased by 80.26% compared to 91.2% in traditional farms. But, for fertilizers, mechanized farms needed 81.41% cost increment compared to 76.20% of traditional farms.

Table 7: Estimation of MVP, efficiency ratio and returns to scale of mechanized and traditional rice farms in study areas

Variables	Mechanized				Traditional			
	MVP	MFC	r	D	MVP	MFC	r	D
Log seed cost	0.733	1	0.733	36.33	0.69	1	0.69	44.86
Log manures	5.067	1	5.067	80.26	11.36	1	11.36	91.20
Log fertilizers	5.379	1	5.379	81.41	4.20	1	4.20	76.20
Log bio/ chemical pesticides	16.209	1	16.209	93.83	12.64	1	12.64	92.09
Log irrigation cost	16.454	1	16.454	93.92	32.31	1	32.31	96.91
Log machine cost	3.836	1	3.836	73.93				
Log human labor cost	-3.348	1	-3.348	129.87	-1.06	1	-1.06	194.63
Log animal power cost	-1.581	1	-1.581	163.25	0.61	1	0.61	63.46

Note: MVP = Marginal Value Productivity, MFC= Marginal Factor Cost, r = Ratio

IV. DISCUSSION

The seed cost had non-significant effect in both types of farms because of use of seed by the farmers more than recommended already. Effect of manures, fertilizers and bio- and chemical pesticides was positive and significant in both types of farms, whereas effect of irrigation to total income was found significant in mechanized and it was not significant in traditional rice farms. The reason for significant positive relation of manures and fertilizers, bio and chemical fertilizers was due to lower use of these resources in both types of farms. Suleiman and Ibrahim (2014) who compared the relative economic efficiency of mechanized and non-mechanize rice Farmers Nigeria also revealed fertilizers was under-utilized and seed was over-utilized for both types of farm i.e. mechanized and non-mechanized. The result from current study was also consistent with Suleiman and Ibrahim (2014) for labor in mechanized farm with the status being over utilized. The finding was similar to the study of Dhakal et al (2019) who showed fertilizers, machinery and pesticides were under used resources in Chitwan district of Nepal. Reja (2013) also computed the resource use efficiency in rice production with special focus on mechanization and found similar results for fertilizers and insecticides with the status being under-utilized in power tiller operated farm and bullock operated farm in Bangladesh.

V. CONCLUSION

The study was conducted to assess the resource use efficiency in mechanized and traditional rice farms from 494 respondents (274 mechanized and 220 traditional rice farms). Survey was conducted in Jhapa, Sunsari and Bardiya district of Nepal. The contribution of machinery to total income in mechanized rice farms was highest and was significant. In traditional farms, it was fertilizer cost that had highest contribution to total income from the rice crop. Increase in human labor was found to decrease the income from crop, which indicated the necessity of replacing additional labor cost by machines. The effect of animal power to total income was not significant. There was decreasing returns to scale in all the farms. Production resources in the study area were found not to be efficiently utilized to optimum economic advantage for both mechanized and traditional rice farmers. Based on the result obtained, it can be concluded that mechanized rice production is more efficient in resource utilization and subsequently more profitable. Findings from this study revealed that rice producers were technically inefficient in the use of farm resources. Overall resource use efficiency illustrated that basic inputs of production (manures, fertilizers, plant protection measures and machines) were underutilized and seeds, human and animal labor were overused.. This situation of underutilization of these resources should be overcome by increasing farmers' access to these inputs and encouraging them to use in higher amount to realize higher return. Assurance of quality and timely supply of fertilizers, plant protection materials and investment on irrigation infrastructure should be done by government authority to increase resources use by farmers. There is a need to provide training for optimum use and awareness to farmers to reduce overuse. Moreover, technology packages for adequate and timely application of these inputs should be delivered to the farmers to maximize returns through increased resource use efficiency.

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