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COMPARATIVE ANALYSIS OF RESOURCE USE EFFICIENCY UNDER LASER LAND LEVELLING AND CONVENTIONAL LAND LEVELLING IN COTTON-WHEAT CROPPING PATTERN OF SIRSA

Dinesh Kumar[1], Dalip Kumar Bishnoi[2], Vinay Mehla[3] and Anil Kumar Malik[4]

ABSTRACT

The research has compared the role of laser land levelling (LLL) in conserving resource in comparison with Conventional land levelling (CLL) and to quantify resource use efficiency under two popular methods of levelling in Sirsa district of Haryana during 2019-2020. Sirsa was selected purposively because of highest area under cotton-wheat cropping pattern in Haryana. Explanatory variables i.e seed, plant protection chemicals, machine labour, irrigation, human labour were taken to regress yield. Difference between marginal value productivity (MVP) and marginal factor cost (MFC) was taken as parameter for estimating resource use efficiency. Highest and lowest resource use efficiency in case of cotton under LLL was of input irrigation and seed respectively and under CLL was of input labour and plant protection chemicals (PPC) respectively. In case of wheat highest and lowest resource use efficiency under LLL was observed of machine and PPC respectively under CLL was of fertilizer and seed respectively. The study confirmed resource conservation potential of LLL. Most significant effect was observed on irrigation and fertilizer which was validated by results that difference between MVP and MFC were obtained to be positive and closer to zero. Therefore, study strongly recommended adoption of this scale neutral resource conserving technology in order to attain efficient utilisation of scarce resources.

(Keywords : Resource use efficiency, variables, laser land levelling, scale neutral)

INTRODUCTION

Agriculture sector is backbone of Indian Economy. It contributes 14.4 per cent to GDP of India. It generates employment to 43.21 per cent of total population. It is growing at rate of 2.9 per cent. Gross cropped area and net sown area is 198.36 million hectare and 140.13 million hectare, respectively. With reference to Haryana, Agriculture contributes to 50.2 per cent to Gross State Domestic Product (GSDP) and growing at 5.5 per cent. Average landholding size in Haryana is 1.58 hectare as compared to national average 1.08 hectare. Gross cropped area and net sown area in state is 6.5 and 3.0 million hectare, respectively. Of the total geographical area *i.e.* 4.42 million hectare in state, 80 per cent is under cultivation and the irrigated area constitutes 84 per cent of cultivated area. The cropping intensity of the state is 181 per cent. Haryana is often called as "Food Basket" of country. It falls in agro climatic zone-VI, which is called as "Trans Gangetic Plains Region". The four main geographical features of state are: Shiwalik hills, Ghaggar-Yamuna plain, Semi-desert sandy plain and Aravalli hills.

The dominant cropping systems are Rice-Wheat, Cotton-Wheat and Pearl millet-Wheat. There is also shift from cotton belt to rice belt in recent years. Mono-culturing of Rice-Wheat along with high relative humidity has aggravated incidence of diseases and insect-pests attacks, which eventually led to higher usage of plant protection chemicals. On other hand, health of soil is deteriorating continuously and there is stagnation in yield. As per a research, if trends in consumption pattern remain same, India will need to produce at least 37 per cent more rice and wheat by 2025 as compared to year 2000, with nearly 10 per cent less water availability (Jat *et al.,* 2006).

Gill (2014) experimented a project entitled - "An Assessment of the impact of laser-assisted precision land levelling technology as a component of climate smart agriculture in state of Haryana, India". To carry out the study Karnal was selected purposively because it has largest number of "climate smart village". Climate smart village concept includes promotion of various climate smart technologies which includes laser land levelling (LLL). An attempt was made to examine synergies and complementarities between laser land levelling (LLL) and

1. Ph.D. Scholar, Dept. of Agricultural Economics, CCSHAU, Hisar
2. Assistant Scientist, Dept. of Agricultural Economics, CCSHAU, Hisar
3. Assistant Scientist, Dept. of Agricultural Economics, CCSHAU, Hisar
4. Sr. Res. Fellow, Dept. of Extension Education, CCSHAU, Hisar

other similar technologies. Twenty five farmers of climate smart village having their own laser land leveller were interviewed using semi-structured schedule which allows flexibility of answers. Study revealed that internal rate of return of laser land levelling machine varies from 120 per cent with diesel low lift pumps to 115 per cent with tube wells. In both of these cases it was observed that payback period was less than one year. Further, it was found that demand of laser land leveller grown exponentially over a period of time. Study revealed role of LLL in mitigating climate change by reducing greenhouse gases emissions because of three reasons (1) On an average it was estimated that 63600 MT of carbon dioxide equivalent was annually reduced due to reduced pumping time under LLL. (2) On an average 3.4 hours ha^{-1} $annum^{-1}$ of tractor time was reduced which resulted in fuel saving of about 7.5 million liter of diesel which ultimately lowered carbon dioxide emissions by 19510 MT annually (3) There was 10-25 per cent decrease in urea application due to good crop stand because laser land levelling reduced low and high spots in field. Thus, N_20 emissions were reduced and also effect of N_20 is 310 times effect of carbon dioxide in causing global warming. It was also revealed by investigation that application of laser land levelling resulted in increment of 2.85 and 3.22 quintal ha^{-1} in wheat and rice, respectively which ultimately leads to additional increment in production of 155 and 750 thousand tons annually of wheat and rice, respectively. Effect on employment generation was also noticed. Laser land levelling generated seasonal employment (2 to 2 ½ months) for semi-skilled labourers of 80 man days $annum^{-1}$ $machine^{-1}$. However, wages of laser land leveller driver was 500 to 550 rupees which was more than a male agricultural labourer. The main reason behind this employment generation was intensive use *i.e.* usually 18 hours day^{-1} during peak season of laser land levelling machines. Project highlighted some synergies of laser land levelling with other climate smart technologies like - Laser land levelling facilitated elimination of bunds which made it easier to use turbo seeder and zero till planter and LLL before seed drill helped in even the distribution of moisture resulted in uniform and increased germination. Also, laser land levelling technology helped in crop diversification specifically of vegetable cultivation because it was easier to grow vegetable under good water control and it was easier to create raised beds on levelled fields. Hence, considering need of hour Laser land levelling technology is ultimate technology to conserve and help in efficient utilization of scarce resources and study has tried to quantify its resource conserving potential.

MATERIALS AND METHODS

Cobb-Douglas production function was fitted taking yield as dependent (regressand) variable while, 6 variables i.e Seed, Fertilizer, PPC, Irrigation, Machine labour, Human labour were taken as independent (regressor) variables. Model fitted was as follows –

$$Y=ax_1^{b1}.x_2^{b2}.x_3^{b3}.x_4^{b4}.x_5^{b5}.x_6^{b6}.U$$

Where,

Y = gross income (Rs. ha^{-1})

a = constant

x_1 = Machine hours (hrs ha^{-1})

x_2 = Labour (man days ha^{-1})

x_3 = Seed (kg ha^{-1})

x_4 = Fertilizer (kg ha^{-1})

x_5 = Plant protection chemicals (g ha^{-1})

x_6 = Irrigation (hrs ha^{-1})

U = Random disturbance term

b_i = (i = 1 to 6) indicate the regression coefficient of factor inputs

Sampling design

Purposive and multistage random sampling technique was used for the selection of districts and villages. The study was carried out in Sirsa district of Haryana. This district was purposively selected on the basis of highest area under cotton-wheat pattern in Haryana. From Sirsa, two blocks were selected randomly. Further, twenty (20) adopters and ten (10) non-adopters farmers of laser land levelling technology were taken randomly from each selected block. Thus, a total of 60 sample farmers were interviewed for the investigation.

Marginal value product and resource use efficiency

Marginal value product is final value of additional output produced by utilizing an additional unit of variable input. The ratio of marginal value product to marginal factor cost can be an effective tool in determining resource use efficiency. Decision rules under this method are as follows: if,

MVP/MFC >1, It shows underutilization of input/ resource and optimum level of resource use is not reached yet.

MVP/MFC =1, It shows efficient utilization of input/ resource use and resource is used at optimum level.

MVP/MFC <1, it over utilization of input/resource use and resource has crossed optimum level of resource use.

Where,

MVP = Change in output due to unit change in input/resource

MFC = Price of a single unit of variable resource.

In Cobb-Douglas production function, marginal value product (MVP) of Xi input is given as follows

$$\text{MVP of Xi} = \frac{\bar{Y}\bar{Y}}{\bar{X}\bar{X}} \times b_i$$

Where,

$\bar{Y}\bar{Y}$= Geometric mean of output/yield (Y)

$\bar{X}\bar{X}$ *i*= Geometric mean of resource x_i

b_i = Output elasticities of x_i

In layman's language, marginal factor cost is nothing but cost of a unit variable input or price of additional unit of input.

MFC = Price of Xi

Resource use efficiency is considered when there is equality of marginal value product and price of input resulting in profit maximization, *i.e.* MVPi = Pi

Where, Pi is the price of unit quantity of input Xi.

Deviations of marginal value product from price are regarded as resource use inefficiency. Higher the difference between marginal value product and price of variable input higher is resource use inefficiency and vice-versa.

To test the significance of these deviations t test was employed. Expression of t test is -

$$t = \frac{MVPi - Pi}{S.E.of\ MVPi}$$

Where, MVPi is the marginal value product of i^{th} input and P_i is its acquisition cost or price of input and standard error of MVP was calculated by multiplying Standard error of regression coefficients to ratio of yield and corresponding input at geometric mean level.

RESULTS AND DISCUSSION

Regression analysis and resource use efficiency of cotton in Sirsa district under LLL vis-à-vis CLL

Regression analysis and resource use efficiency of cotton under laser land levelling (LLL) and conventional land levelling (CLL) in Sirsa district of Haryana are presented in Table 1. The results of analysis are as follows:

Laser Land Levelling (LLL)

Study revealed that in case of laser land levelling in Sirsa district, among the six explanatory, regression coefficients of fertilizer and irrigation were found to be positive and had significant impact on cotton yield. However, regression coefficients for seed and plant protection chemicals were found positive but had non-significant impact on cotton yield. While, regression coefficients for machine and labour were found to be negative and had non-significant impact on cotton yield. Coefficient of determination (R^2) was 0.662 showing that 66.2 per cent of total variations in dependent variable were explained by independent or explanatory variables.

In order to examine resource use efficiency, marginal value productivity and marginal factor cost was worked out. In case of laser land levelling in cotton crop, the difference between MVP and MFC were found to be positive for inputs viz., machine, seed, fertilizer, irrigation and plant protection chemical indicating these inputs are underutilized so that more of these inputs can be used to increase the cotton productivity under laser land levelling. Whereas, the difference between marginal value productivity (MVP) with its unit price (MFC) for human labour were found to be negative and non-significant indicated over utilization. Highest resource use efficiency was found to be of irrigation while, least resource use efficiency was found to be of seed because difference between MVP and MFC was most close and most far from Zero (efficiency level) in case of these inputs respectively. On the same lines, Aryal *et al.* (2014) tried to access impact of laser land levelling in rice-wheat cropping system of Northern India. Major outcomes of research revealed that laser land levelling reduced irrigation time in wheat and rice by 10-12 and 47-69 hours $hectare^{-1}$ $season^{-1}$, respectively. Incremental productivity was observed due to use of laser land levelling (LLL) in rice-wheat was 7 per cent and 8.8 per cent, respectively. Study showed that laser land levelling (LLL) was a scale neutral technology. Also, it was experienced that due to reduction in irrigation time about 300 to 410 litres of diesel $hectare^{-1}$ $year^{-1}$ and 558 to 762 kilowatt hour of electricity $hectare^{-1}$ $year^{-1}$ was saved which ultimately decreased farmer's cost and environmental pollution.

Conventional land levelling (CLL)

In case of conventional land levelling, results of regression analysis highlighted that regression coefficients of machine and fertilizers were found to be positive and had significant impact on cotton yield. However, regression coefficients of labour and irrigation were found to be positive but had non-significant impact on yield of cotton. Whereas, regression coefficients of seed and plant protection chemicals were observed to be negative and had non-significant impact on cotton yield. Coefficient of determination (R^2) was 0.736 showing that 73.6 per cent of total variations in dependent variable were explained by independent or explanatory variables.

As far resource use efficiency is concerned, difference between MVP and MFC was found to be positive for inputs viz., machine, seed, fertilizer, irrigation and plant protection chemicals was said to be underutilization of these inputs. Whereas, in case of labour, the difference between MVP with its units price (MFC) was found to be found negative and non–significant indicting over utilization of human labour. Highest resource use efficiency was found to be in labour and least resource use efficiency was found to be in plant protection chemicals because difference between MVP and MFC is most close and most far from zero (efficiency level) in case of these inputs, respectively. These results are in accordance with findings of Jat *et al.* (2011) ,who conducted an experiment from 2002 to 2004 at Modipuram to examine benefits of precision land levelling along with crop establishment techniques *i.e.* furrow irrigated raised bed planting system. It was revealed from study that agronomic and uptake efficiency of N, P, K seemed to be improved significantly under precision land levelling with raised bed as compared to conventional land levelling with flatbeds. Specifically in wheat it was experienced that yield was improved by 16.6 per cent and irrigation water was reduced by 50 per cent in precision land levelling on raised bed as compared to conventional land levelling on flatbeds.

Regression analysis and resource use efficiency of wheat in Sirsa district under LLL vis-à-vis CLL

Regression analysis and resource use efficiency of wheat under laser land levelling (LLL) and conventional land levelling (CLL) in Sirsa district of Haryana are presented in Table 2. The results of analysis are as follows:

Laser Land Levelling (LLL)

Regression analysis and resource use efficiency of wheat in Sirsa district of Haryana under laser land levelling and conventional land levelling are presented in Table 2. Under laser land levelling, The results of regression analysis revealed that among the six explanatory variables, plant protection chemicals and irrigation were found to be positive and had significant while,in case of machine and fertilizer was found to be positive but had non-significant impact on wheat yield. While, seed and labour was found to be negative and had non-significant impact on yield of wheat. Coefficient of determination (R^2) was 0.473 showing that 47.3 per cent of total variations in dependent variable was explained by independent variables.

In case resource use efficiency, difference between marginal value productivity (MVP) and marginal factor cost (MFC) were found to be positive for inputs viz., fertilizer, plant protection chemicals and irrigation was said to be under-utilization of these inputs exhibited more use of these inputs may help in enhancement of wheat productivity. Whereas, difference of MVP and MFC was observed to be negative for inputs like machine, labour and seed indicating over-utilization of these inputs, therefore, need to be reduced the use of these inputs for enhancement of profitability from wheat cultivation under laser land levelling. Highest resource use efficiency found to be that of machine and least resource use efficiency was found to be in plant protection chemicals because difference between MVP and MFC was most close and most far from zero (efficiency level) in case of these inputs respectively. On the same lines, Sapkal*et al.* (2019) conducted an experiment to evaluate economic benefits of laser land levelling and revealed that 55 per cent and 12 per cent of total deviations in productivity of Wheat and Paddy respectively was observed due to laser land levelling and rest due to change in input level. LLL has been proven a boon for Paddy-Wheat system because of its water saving potential and improved productivity. Major constraints highlighted in study were lack of technical know-how and high cost of levelling field by laser leveler. So, study suggested to increase knowledge level of farming community with the help of Agricultural extension Agencies to increase adoption of LLL at wider scale.

Conventional land levelling (CLL)

In case of conventional land levelling results of regression analysis revealed that regression coefficients of labour were found to be positive and had significant impact on wheat productivity. However, machine, seed, fertilizer, plant protection chemicals and irrigation was found positive but had non-significant impact on wheat yield. Coefficient of determination (R^2) was 0.338 showing that 33.8 per cent of total variations in dependent variable were explained by independent variables.

Difference between MVP and MFC was found to be positive for inputs like machine, seed, fertilizer and plant protection chemicals indicating underutilization of these inputs, suggested to more use of these inputs may increase the productivity of wheat. While, in case of labour and irrigation, the difference between MVP and MFC were observed to be negative for said to be overutilization of these inputs advised less use of these inputs may increase the profitability of wheat under conventional land levelling. Highest resource use efficiency was found to be that of fertilizer while least resource use efficiency was found to be of seed because difference between MVP and MFC was most close and most far from zero (efficiency level) in case of these inputs respectively. Shahani *et al.* (2016) conducted a study on economic viability of LLL and found that revenue were higher under laser land levelling (Wheat - Rs 35264 and Cotton – Rs 102610) acre^{-1} as compared to conventional land levelling (Wheat - Rs30723 and Cotton – Rs 92960) acre^{-1} respectively. Also, it was concluded that laser land levelling holed in reduction of 21 per cent of irrigation water and that saved water can be used for increasing area under irrigation and crop survival during water shortage.

It can be concluded from regression analysis that with the adoption of laser land levelling we can't predict resource use of inputs viz., seed, labour, machine hours and plant protection chemicals with certainty because MVP varied for crops under study. But we can predict with certainty that adoption of laser land levelling avoids misuse of fertilizer and water inputs and increased resource use efficiency of these inputs. This can be validated by results that difference between marginal value productivity (MVP) and marginal factor cost (MFC) were obtained to be positive and closer to zero for irrigation and fertilizer under LLL as compared to CLL indicated uses of these inputs towards near to efficient utilization in laser land levelling technology in cotton – wheat cropping pattern in the study area. Similarly, Sindhu *et al.* (2010) studied impact of laser land levelling (LLL) mainly in rice field. Empirical evidence showed that laser land levelling could reduce water use in rice by 36.93 cm and increased yield by 7.8 per cent hectare^{-1}. Though, electricity was supplied at almost free of cost but reduction in water use attributed to 213.35 Kilowatt hour decrease in electricity consumption which reduced cost of electricity for government by Rs 610 hectare^{-1}. Total economic benefits from using laser land levelling (LLL) were found to be Rs. 8207 hectare^{-1}. It was also estimated that laser land levelling could save 0.99 million hectare meter of water and 583.51 million kilowatt hour of electricity in whole Punjab. Also, all farming group could have incremental returns of Rs. 2078 crore year^{-1} and total economic benefits of laser land levelling to Punjab could be Rs. 2245 crore.

Table 1. Regression analysis and resource use efficiency of cotton under LLL and CLL in Sirsa district of Haryana

	Intercept		Machine		Labour		Seed		Fertilizer		PP		CIrrigation	
	LLL	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**
B	5.85*	3.06	-0.01	0.43*	-0.06	0.17	0.01	-0.18	0.32*	0.52**	0.15***	-0.25	0.23*	0.20
SE	1.79	2.99	0.14	0.15	0.08	0.13	0.15	0.14	0.10	0.20	0.08	0.30	0.08	0.13
t	3.28	1.02	-0.07	2.94	-0.74	1.29	0.04	-1.33	3.17	2.66	1.72	-0.84	2.91	1.57
MVP			-0.13	6.56	-0.14*	0.33*	0.16	-4.91	5.06	7.90	2.61	-4.28	3.92	3.02
SE			1.81	2.23	0.18	0.26	4.41	3.69	1.60	2.97	1.52	5.12	1.34	1.93
MFC			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DIFF			0.81	1.23	-0.82	-0.74[@]	3.41[#]	2.69	0.60	1.97	0.52	4.12[#]	0.34[@]	0.93
t			0.45	0.55	-4.42	-2.89	0.77	0.73	0.37	0.66	0.34	0.80	0.26	0.48

LLL = Laser land levelling, CLL = Conventional land levelling, PPC = Plant protection chemicals

$R^2_{LLL} = 0.662$ $R^2_{CLL} = 0.736$

*Significance at 1% level, **Significance at 5% level, ***significance at 10% level

[#] Least resource use efficiency [@] Highest resource use efficiency

Minus sign in Row of Diff (MVP – MFC) shows overutilization and positive value shows underutilization

Table 2. Regression analysis and resource use efficiency of wheat under LLL and CLL in Sirsa district of Haryana

	Intercept		Machine		Labour		Seed		Fertilizer		PP		CIrrigation	
	LLL	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**	**LLL**	**CLL**
B	11.04*	5.70***	0.05	0.16	-0.05	0.07	-0.09	0.22	0.09	-0.09	0.11***	0.05	0.08	0.03
SE	1.65	3.20	0.05	0.27	0.05	0.11	0.11	0.27	0.15	0.26	0.04	0.09	0.06	0.06
t	6.70	1.78	0.88	0.61	-1.06	0.67	-0.83	0.81	-0.56	0.34	2.67	0.52	0.44	0.54
MVP			0.54	1.95	-0.14*	0.19*	-3.64	8.50	1.20	-1.18	8.42**	3.25	1.50	0.53
SE			0.62	3.21	0.14	0.28	4.38	10.51	2.15	3.48	3.16	6.26	1.12	0.99
MFC			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DIFF			-0.46[@]	0.95	-1.14	-0.81	-4.64	7.50[#]	0.20	-0.18[@]	7.42[#]	2.25	0.50	-0.47
t			-0.74	0.30	-8.36	-2.95	-1.06	0.71	-1.02	0.05	2.35	0.36	-0.45	-0.48

LLL = Laser land levelling, CLL = Conventional land lavelling, PPC = Plant protection chemicals

$R^2_{LLL} = 0.473$ $R^2_{CLL} = 0.338$

*Significance at 1% level, **Significance at 5% level, ***significance at 10% level

[#] Least resource use efficiency [@] Highest resource use efficiency

Minus sign in Row of Diff(MVP – MFC) shows overutilization and positive value shows underutilization

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