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Research Paper

Effect of Laser Land Levelling on Paddy-Wheat and Cotton-Wheat Cropping Pattern in Haryana

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ABSTRACT

The study has quantified and compared the effect of laser land levelling technology with conventional land levelling in paddy-wheat and cotton-wheat cropping pattern in Karnal and Sirsa district of Haryana state, respectively. Using Bisaliah decomposition model (1977) improved technology and change in input use to enhance productivity under laser land levelling has been assessed. Decomposition of total productivity highlighted that in Karnal district, out of total incremental change in productivity, 8.38 and 5.36 per cent change was contributed only due to change in technology and rest was due to input use in paddy-wheat, respectively. Similarly, in Sirsa district, out of total change in productivity 5.4 and 4.87 per cent change contributed only due to enhancement in technology while rest was due to input use in cotton-wheat cropping pattern, respectively. Further study highlighted that water as well as fertilizer use efficiency was most influenced by use of laser land levelling technology. On the account of results of study, it was concluded that laser land levelling is an effective scale neutral resource conservation technology which has immense potential to cure low water use efficiency and improve fertilizer use in most prevalent cropping patterns (i.e. paddy-wheat as well as cotton) of Haryana state.

Highlights

- Major contribution in total productivity was due to technological change by adoption of laser land levelling technology followed by input use.

Keywords: Laser land levelling, Conventional land levelling, Scale neutral, Efficiency, Decomposition

About 62 per cent area of Haryana state is under poor quality of water. State is facing problems of declining as well as rising water tables, soil salinity/ alkalinity (0.23 million ha), declining soil health and stagnating crop productivity. Agriculture being largest beneficiary of ground water, declining ground water table will impact sustainability and food security (Aggarwal *et al*. 2004; Kerr, 2009; Kumar *et al*. 2007). According to Ranjan Aneja, an economist in Central University of Haryana, the share of Haryana's districts which have developed depleted water reserves to "dangerous" levels has raised from 63 per cent in 1995 to 89 per cent in 2014. Ground water table is continuously shrinking in state due to over extraction of water to fed rice-wheat crop rotation. According to the Central Water Commission's data, the average depth at which ground water was available in 1975 was 9.19 meter which plummeted to 18.66 meter in year 2016. Primary cause of decline in water table is practicing of water-hungry crops such as paddy-wheat crop rotation. Various investigations were conducted and suggested that in Haryana, paddy-wheat crop rotation is unsustainable and is lowering the water table.

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The increased popularity of these crops may be attributed to remunerative prices for rice and wheat, not only for meeting food and nutritional security, but also resulted in draining out the excess water brought about due to unlined canals and lack of adequate drainage in state. Cultivation of these above mentioned crops over long period of time has brought significant decline in ground water levels and leading to overexploitation of ground water resources. As per the estimates of Central Ground Water Board (CGWB) estimated in collaboration with the Haryana government revealed that annual ground water resources which can be self replenishable in the state is 9130.51 million cubic meter (MCM) against the withdrawal of 12500.38 million cubic meter, leading to exploitation of ground water.

Despite this critical problem of water crisis, farmers are continuously growing paddy, which requires 80 per cent more water compared to maize because electricity is provided at almost free of cost and farmers have minimum incentives to conserve it and hence it act as positive externality. In the 1960s, these types of subsidies, in addition to high yielding seeds and fertilizer had led to green revolution in India, whose benefits are now denigrating and dwindling continuously. So, resource conservation technology is need of hour and laser land levelling is ultimate technology to conserve most precious resource *i.e.* water.

Farmers in Haryana now practice two technologies for levelling of land: Conventional land levelling (CLL) and Laser land levelling (LLL). In Paddy-wheat cropping pattern of the Northern alluvial Plains, about 10-25 per cent of irrigation water is lost due to poor management and uneven fields (Kahlown *et al*. 2000). Laser land levelling facilitates uniformity in the placement of seeds/seedlings and promotes better crop stands, which contributes to higher yields. Adoption of laser land levelling under various cropping systems and agro-climatic conditions has resulted in reduction of water uses up to 15-30 per cent and increase 3-6 per cent of total cultivable area due to reduction in bunds and channels in the field by laser assisted precision land levelling.

Moreover, cost of cultivation has increased many folds due to rising prices of agricultural factors and fuels. The existing crop production technologies leads to overuse of most scarce resource on this planet *i.e.* water causing higher degree of resource use inefficiency. Therefore, application of laser land levelling (LLL) has the potential to increase crop productivity with less use of water, energy and fertilizer inputs as compared with traditional levelling practice. In India, where water and energy scarcities are increasing, application of LLL holds tremendous potential for saving these resources and increasing yields that are currently stagnating.

It is therefore, felt imperative need to evaluate and decompose the effect of laser and conventional land levelling on paddy-wheat, cotton-wheat cropping patterns with the aid of Bisaliah decomposition model.

MATERIALS AND METHODS

The study was focused in Karnal and Sirsa districts of Haryana. These districts were selected as per purposive sampling on the basis of highest area under paddy-wheat and cotton-wheat pattern, respectively in Haryana. From each districts, two blocks were selected at random. Further, twenty (20) adopters and ten (10) non-adopters farmers of laser land levelling technology were selected at random from each selected block. Thus, a total of 120 sample farmers were contacted for the investigation.

Due to convenience in study following form of Cobb-Douglas production function was used to decompose the effect of laser land levelling technology. The general form of the production function 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 (₹ / ha); a = constant; x_1 = Machine hours (hrs/ha); x_2 = Labour (man days/ha); x_3 = Seed (kg/ha); x_4 = Fertilizer (kg/ha); x_5 = Plant protection chemicals (g/ha); x_6 = Irrigation (hrs/ha); U = Random disturbance term; b_i = (i = 1 to 6) indicate the regression coefficient of factor inputs.

Above equation of Cobb-Douglas production function is exponential form and using this form was a tedious task to decompose technology impact. So, this form was converted from exponential form to linearized form by applying log operation and was written as below:

Production function under laser land levelling

$$Y_{LLL} = b_0 x_{1LLL}^{b1} . x_{2\,LLL}^{b2} . x_{3LLL}^{b3} . x_{4LLL}^{b4} . x_{5LLL}^{b5} . x_{6LLL}^{b6} . U_{LLL} \quad \ldots(1)$$

Production function under conventional land levelling

$$Y_{CLL} = a_0 x_{1CLL}^{a1} . x_{2CLL}^{a2} . x_{3CLL}^{a3} . x_{4CLL}^{a4} . x_{5CLL}^{a5} . x_{6CLL}^{a6} . U_{CLL} \quad \ldots(2)$$

Taking log of (1) and (2)

$$LnY_{LLL} = Lnb_0 + b_1 LnX_{1LLL} + b_2 LnX_{2LLL} + b_3 LnX_{3LLL} + b_4 LnX_{4LLL} + b_5 LnX_{5LLL} + b_6 LnX_{6LLL} + U_{LLL} \quad \ldots(3)$$

$$LnY_{CLL} = Lna_0 + a_1 LnX_{1CLL} + a_2 LnX_{2CLL} + a_3 LnX_{3CLL} + a_4 LnX_{4CLL} + a_5 LnX_{5CLL} + a_6 LnX_{6CLL} + U_{CLL} \quad \ldots(4)$$

Bisaliah decomposition model (1977) was deliberately used to quantify the effect of various sources to productivity difference under LLL and CLL. According to this change in productivity is mainly due to two reasons *i.e.* technological change and input use. Further, technological change is of two types – neutral and non-neutral. Neutral technological change is due to intercept term in model and non-neutral technological change is change in regression coefficients keeping input level fixed.

Subtracting equation 4 from 3 we get,

$$Ln[Y_{LLL}/Y_{CLL}] = \{Ln(b_0/a_0)\} + \{(b_1 - a_1)LnX_{1CLL} + (b_2 - a_2)LnX_{2CLL} + (b_3 - a_3)LnX_{3CLL} + (b_4 - a_4)LnX_{4CLL} + (b_5 - a_5)LnX_{5CLL} + (b_6 - a_6)LnX_{6CLL}\} + \{b_1 Ln(X_{1LLL}/X_{1CLL}) + b_2 Ln(X_{2LLL}/X_{2CLL}) + b_3 Ln(X_{3LLL}/X_{3CLL}) + b_4 Ln(X_{4LLL}/X_{4CLL}) + b_5 Ln(X_{5LLL}/X_{5CLL}) + b_6 Ln(X_{6LLL}/X_{6CLL})\} + \{U_{LLL} - U_{CLL}\} \quad \ldots(5)$$

Equation 1 is production function under LLL while equation 2 is production function under CLL. For decomposition, we subtracted equation 4 from equation 3 and get equation 5. In equation 5, term on left hand side of equal sign represents percentage expected change in productivity, first bracketed term on right hand side of equal sign represents neutral technological change, second bracketed term represents non-neutral technological change weighted by input use expenditure under conventional land levelling, third bracketed term represents contribution of input change to productivity weighted to regression coefficients under laser land levelling and last bracketed term represents error term in model and it could not be taken into account.

RESULTS AND DISCUSSION

Bisaliah output decomposition model (1977) was incorporated in the study to segregate the impact of technology and input change in productivity differential. Technology can affect productivity by shifting slope and scale parameters of production function. (Bisaliah, 1977). Negative contribution of inputs indicates resource conserving nature of laser land levelling technology.

Output decomposition of paddy –wheat in Karnal district of Haryana state is shown in Table 1. In case of paddy, difference in productivity was estimated to be 4.901 per cent, which includes the effect of technology and input change. Out of this, 8.381 per cent impact was due to difference in technology and -3.480 per cent were due to alteration in inputs. It shows that farmers could increase 8.381 per cent productivity in paddy only by adopting laser land levelling instead of conventional land levelling. Among inputs, major contribution (but negative) was of irrigation (-2.403%). Only machine labour had positive impact on productivity while all other inputs had negative impact on productivity. Total observed difference in productivity was 4.902 per cent while error in estimation due to random term was 0.001 per cent showing accuracy of model.

Similarly, it was observed in wheat in Karnal district that difference in productivity was estimated to be 4.739 per cent which includes effect of technology and input change. Out of this 5.360 per cent contribution was due to difference in technology and -0.621% was due to change in inputs. It indicated that farmer could increase 5.360 per cent of productivity in wheat (Karnal) only by adopting laser land levelling instead of conventional land levelling. Among inputs, major contribution (positive) was of machine labour 2.537 per cent. Only machine labour has positive impact on productivity while all other input have negative impacts. Total observed difference in productivity was 4.745 per cent while error in estimation due to random term was 0.006 per cent showing accuracy of the model.

Table 1: Bisaliah output decomposition model in Karnal district of Haryana

Sl. No.	Source of productivity difference	Karnal	
		Paddy	Wheat
A	Total observed difference in productivity	4.902	4.745
B	Due to difference in technology	8.381	5.360
1	Machine labour (X_1)	0.993	2.537
2	Human labour (X_2)	-0.349	-0.882
3	Seed (X_3)	-0.065	-0.130
4	Fertilizer (X_4)	-1.633	-0.015
5	Plant protection chemicals (X_5)	-0.023	-0.718
6	Irrigation (X_6)	-2.403	-1.413
C	Due to difference in input use level(1-6)	-3.480	-0.621
D	Total estimated difference (B + C)	4.901	4.739
E	Error in estimation due to random term	0.001	0.006

In cotton crop in Sirsa district, difference in productivity was estimated as 2.841 per cent, which includes effect of technology and input change. Out of this 5.440 per cent contribution was due to difference in technology and -2.601 per cent were due to change in inputs. It shows that farmers could increase 5.40 per cent productivity in cotton only by adopting laser land levelling instead of conventional land levelling. Among inputs, major contribution (but negative) was of irrigation -1.814 per cent. Contribution of all the inputs was negative showing resource conservation nature of laser land levelling technology. Total observed difference in productivity was 2.842 per cent while error in estimation due to random term was 0.001per cent showing accuracy of model.

Similarly, in wheat (Sirsa) difference in productivity was estimated as 5.022 per cent which includes effect of technology and input use. Out of this 4.872 per cent was due to difference in technology and 0.15per cent was because of change in inputs. It shows that farmers could increase 4.872 per cent productivity in wheat (Sirsa) only by adopting laser land levelling instead of conventional land levelling. Among inputs, major contribution was of plant protection chemicals (ppc) -0.643 per cent. Inputs like machine, human labour, seed and fertilizer had positive impact while irrigation and plant protection chemicals had negative impact on productivity. Total observed difference in productivity was 5.022 per cent while error in estimation due to random disturbance term was nil (Table 2).

Table 2: Bisaliah output decomposition model in Sirsa district of Haryana

Sl. No.	Source of productivity difference	Sirsa	
		Cotton	Wheat
A	Total observed difference in productivity	2.842	5.022
B	Due to difference in technology	5.440	4.872
1	Machine labour (X_1)	-0.160	0.437
2	Human labour (X_2)	0.670	0.433
3	Seed (X_3)	-0.027	0.157
4	Fertilizer (X_4)	-0.897	0.163
5	Plant protection chemicals (X_5)	-0.373	-0.643
6	Irrigation (X_6)	-1.814	-0.396
C	Due to difference in input use level (1-6)	-2.601	0.151
D	Total estimated difference (B + C)	2.841	5.022
E	Error in estimation due to random term	0.001	0.000

CONCLUSION

The study emphasized and highlighted that lazer land levelling can be a potential resource conservation technology to mitigate water scarcity problem along with enhancement in productivity in paddy-wheat and cotton-wheat cropping pattern. Moreover, it is a scale neutral technology adopted by each category of farmers. lazer land levelling contributed to increase in productivity in two ways i.e. first by shifting the production function by changing intercept and slope (technological change) and second by reducing input use to produce same quantity of output (input change) and between these two effects technological change was more prominent one as highlighted by 8.38 and 5.36 per cent change due to technology in paddy-wheat, respectively in Karnal district and 5.44 and 4.87 % change in productivity due to technology in cotton-wheat, respectively in Sirsa district. On the basis of findings of the study, it was concluded that laser land levelling is an effective scale neutral resource conservation technology which has immense potential to cure low water use efficiency and improve fertilizer use in most prevalent cropping patterns (i.e. paddy-wheat as well as cotton) of Haryana state.

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