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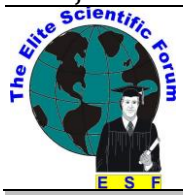

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RESEARCH ARTICLE

Assessment of Economic Impact of Land Laser Leveling in Rice-Wheat and Mixed Cropping Zones of Punjab

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ABSTRACT

Precision agriculture validates the use of advanced machinery for balancing the crop inputs. This study is based on a field survey conducted in the year 2014-15 to appraise the economic impact of the resource-conserving intervention of land laser levelling. Stratified random sampling technique was used for selection of eighty-four (84) farmers from Gujranwala, Sialkot, Hafizabad and Mundi Bahauddin districts in the rice-wheat zone, and Sargodha, Khushab and Jhang districts in mixed cropping zone of Punjab, where the farmers have adopted land laser levelling more and vice versa. Land laser levelling results into saving of irrigation water and labor for its application. The use of technology resulted in a higher yield of major crops to the extent of 10.0 to 18.4%. Although use of the technology is increasing with the passage of time however only 21% of the farmers in rice-wheat cropping zone and 15% in mixed cropping zones have reported to own land laser levellers. Sample farmers having laser levellers reported levelling about three-quarters of operational holdings, while farmers using rented laser-levellers levelled half of the operational holding. As ownership of land laser levellers is limited, thus most of the technology users depend on service providers for land laser levelling. In the survey year, each land laser leveller owner in rice-wheat zone provided services to 13 farmers with a mean area of 10.52 ha (26 acres) per farm. While each of the owner farmers in mixed cropping zone provided services to 5 farmers with a mean area of 13.15 ha (32.5 acres) per farm. Thus, use of the technology is limited to large farmers. However, farmers using land laser levelling gained higher benefit-cost ratios ranged from 0.05 to 0.17 over conventional land levelling. Return to investment on land laser levelling ranged from 3.35 (wheat crop in rice-wheat zone) to 14.49 (maize crop in mixed zone). In conclusion, laser levelling is a resource-conserving technology which can be used successfully for saving precious farm inputs like irrigation, labor and fertilizer etc.

INTRODUCTION

The concept of land laser levelling has been around since at least the early 1970s. It was introduced in the Indo-Pak sub-continent during 1985. In the year 2012, laser-assisted land levelling was being practised over 1.5 million hectares in South Asia. The traditional land levelling, which uses scrapers or levelling boards drawn by draft animals or tractors or even bulldozers in case of highly undulated land, cannot achieve the desired accuracy and hence, is less likely to minimize the uneven distribution of irrigation water (Jat et al., 2006). However, laser land levelling allows for more efficient use of precious water resources by removing unessential depression and raised contours (Naresh et al., 2011). A series of studies on laser levelling in rice-wheat systems of the Indo-Gangetic Plains have found 10-30% irrigation water savings, 3-6% effective increase in farming area, 6-7% increase in fertilizer use efficiency and 3-19% increase in yield (Jat et al., 2009,

and Ren et al., 2003). Bhatt and Sharma (2009) estimated that around 25 to 30% of irrigation water could be saved through this technique without having any adverse effect on the crop yield. It results in a reduction in labor use for weeding by 75%. A considerable increase in the yield of various crops can be obtained by using the technology as a strong correlation exists between the levelness of the land and crop yield (Rickman, 2002). Moreover, it results in the even distribution of moisture, encourages uniform germination, efficient use of nutrients and improves crop stand. Thus, in brief, the technology saves valuable inputs like water, fertilizers and labor, improves crop growth, and results in higher productivity and resource use efficiency (El-Behery and El-Khatib, 2001). Limitations of laser levelling include the high cost of the equipment/laser instrument, the need for a skilled operator to set/adjust laser settings and operate the tractor and restriction to regularly shape fields (Abdullaev et al., 2007). Farmers, as entrepreneurs are unwilling to adopt new technologies unless they see quick and tangible results in terms of farm profitability (Jat et al., 2006). Theoretically, a farmer would opt for a new technology like laser levelling of land if assured of earning a net profit. Some economists believe that the net returns must be at least 30% higher for any new technology than for the traditional technology before farmers would consider adoption (Naresh et al., 2014).

This study presents an appraisal of the economic impact of Resource Conservation Intervention (RCI) of land laser levelling. The study has been conducted in two cropping zones of Punjab viz. rice-wheat zone and mixed cropping zone, where the land laser leveller is being practiced relatively higher than other cropping zones of the country. In Pakistan, the rice-wheat cropping system occupies about 10% of the total cultivated area (2.1 million hectares), mainly in two zones, the Punjab rice-wheat zone, comprising about 1.2 million hectares, and the Sindh rice-wheat zone, occupying the remaining area (Aslam, 1998). Mixed cropping system also occupies a considerable portion of the cultivated area in the country. This study was conducted to analyze the economic impact of land laser levelling in rice-wheat and mixed cropping zones of Punjab, Pakistan.

MATERIALS AND METHODS

The study was based on primary data collected from selected districts of rice-wheat and mixed cropping zones of Punjab, Pakistan in the year 2015. A comprehensive questionnaire was developed for detailed data collection about crop production practices and yield levels from farmers using land laser levelling as well as those not using the technology. Field surveys were conducted in Gujranwala, Sialkot, Hafizabad and Mandi Bahauddin districts from rice-wheat zone, and Sargodha, Khushab and Jhang districts from mixed cropping zone. Stratified random sampling technique was used for data collection i.e. numbers of farmers selected for the interview were based on the adoption of technology in respective districts. The data about adoption of land laser levelling were obtained from district offices of the irrigation department. In total, 84 farmers were interviewed who have implemented this resource conservation technology for the sowing of wheat, rice and other crops from both the zones. Details about the sample size by districts are presented in Table 1.

Data were analyzed for descriptive statistics like mean and standard deviation etc. Effect of land laser levelling on irrigation time and cost of major crops in selected zones, land preparation, soil fertility and total cost of production were determined. Furthermore, gains in using the technology regarding crop productivity and profitability were measured. Similarly, the increase in returns to investment by the adoption of laser levelling was also calculated by following expression.

$$Rate\ of\ Return\ to\ Laser\ Levelling = \frac{Gross\ Returns - Total\ Cost\ Excluding\ Laser\ Levelling\ cost}{Cost\ of\ Laser\ Levelling}$$

RESULTS AND DISCUSSION

Land laser levelling is a water saving technology, thus in cropping systems with high water requiring crops the adoption of technology is relatively higher than other systems. In the study area, 18% of the farmers reported owning laser levellers. Ownership of land laser levellers by the sample farmers in rice-wheat cropping zone and mixed cropping zone was 21% (9 out of 44 farmers) and 15% (6 out of 40 farmers), respectively. Thus, ownership of laser levellers in the rice-wheat zone was higher than in mixed cropping zone by six percent. Farmer and farm characteristics along with details about the use of land laser levelling are presented in Table 2. Farmers having laser levellers had better better educational status than those hiring services for land laser levelling. Farmers having laser levellers were relatively less experienced than their counterparts in the rice-wheat zone, while the opposite was the case in mixed cropping zone. Farmers with large land holdings reported to own laser levellers. Mean operational holdings of the farmers having laser levellers were higher than their counter parts in both cropping zones. Mean operational area of the sample farmers who reported to rent in land laser levellers was about twenty-five acre in both zones. It indicated that farmers having operational land holdings greater than one square (25 acres) purchased their own land laser levellers. Similarly, farmers owning land laser levellers used the technology on large farm area than their

Table 1: Study Districts and Sample Size

Cropping Zone	Selected Districts	Sample Size (Number of farmers)
Rice-Wheat	Gujranwala	24
	Sialkot	01
	Hafizabad	09
	Mandi Bahauddin	10
	Sub Total	44
Mixed	Sargodha	12
	Khushab	02
	Jhang	26
	Sub Total	40
	Total	84

Table 2: Farmer Characteristics and Use of Laser Leveller

Characteristics	Rice-Wheat Cropping Zone		Mixed Cropping Zone	
	Owned	Rented	Owned	Rented
Education (Years)	9.3 (4.7)	6.9 (4.9)	8.0 (4.9)	7.8 (5.0)
Experience (Years)	13.8 (10.6)	19.0 (11.6)	24.3 (12.8)	15.6 (11.1)
Operation Land Holding (Acres)	49.1 (95.3)	23.5 (16.5)	95.9 (68.4)	27.9 (35.4)
Land Levelled on Farm in year 2013-14 (Acres)	35.9 (63.5)	13.4 (11.4)	68.3 (55.6)	13.8 (18.6)
Laser Levelled Land (% Area of Operational Holding)	73.0	57.0	71.2	49.5

Note: Figures in parenthesis are standard deviations

counterparts. In the study year, sample farmers having laser levellers reported laser levelling about three-fourth of operational holdings, while farmers using rented laser levellers levelled almost half of the operational area at their farms. In the survey year, each land laser leveller owner in rice-wheat zone provided services to on an average 13 farmers with a mean area of 26 acres per farm. While each of the owner farmers in mixed cropping zone provided services to 5 farmers with a mean area of 32.5 acres per farm.

The most important beneficial aspects of using laser leveling technology, according to experts, are uniform water dispersal, tillage conservation, enabling agricultural activities, reduced water consumption, and reduced water waste (Far and Rezaei-Moghaddam, 2020). Previously, some researchers including Memon et al. (2015) reported considerable water saving in crop production by laser land levelling i.e. up to one-fifth (21%) of the original level in case of wheat crop and even more in other crops. Land laser levelling is relatively new technology, and farmers are not fully aware to efficiently use it. Therefore, it is observed that farmers usually irrigate crops sown on laser levelled land, as well as non-laser levelled land in the same number. However, irrigation application time decreases to a great extent on laser levelled lands. The results are in line with Aryal et al. (2015) who reported that irrigation time reduced by 47-49 hours per hectare per season in rice crop, and 10-12 hours per hectare per season in case of wheat crop. In wheat crop, use of the technology resulted in savings in cost of irrigation by 26.5% and 28.9% in rice-wheat and mixed cropping zones, respectively (Table 3). Use of the technology for rice crop in rice-wheat crop zone resulted into 15.5% decrease in irrigation cost. Similarly, irrigation cost for sugarcane, cotton and maize crops decreased by 36.2%, 23.8% and 21.8%, respectively. Mean irrigation costs without and with laser land levelling for the selected crops across cropping zones was found to be statically different.

Land preparation cost increased from 15% (maize crop) to 115% (Sugar cane) with the use of land laser levellers. Crop wise details are given in Table 4. Land laser levelling resulted in the low use of soil fertility improving inputs for the wheat crop in both rice-wheat and mixed cropping zones. Thus, cost of soil fertility improving inputs with laser levelling was less than without its use. In case of rice crop, fertilizer and farm yard manure (FYM) cost was higher at laser levelled farms (60%) than non-laser levelled ones. While other crops farmers reported using the same level of fertility improving inputs in case of laser levelling and without laser levelling. With the use of land laser levellers, a decrease of 6.8 % occurred in total cost of production of sugarcane, as water requirement of the crop and irrigation cost decreased considerably.

Previous literature also revealed that use of laser land levelling improved water use efficiency without causing negative impact on crops' output (Bhatt and Sharma, 2009 and Kaur et al., 2012). Singh et al. (2011), Ahuja et al. (2016) and Shahani et al. (2016) also described it as a cost-saving technology with efficient use of inputs and higher crop productivity. At sample farms increase in productivity of major crops was ranged from 5.0% (sugarcane) to 18.4% (cotton) (Table 5). Increase in yield of the wheat crop in rice-wheat and mixed cropping zone were 4.54 mound (13.5%) and 5.06 mounds per acre (14.8%), respectively. While Memon et al. (2015) reported 18% increase in wheat productivity in Sindh province due to land laser

Table 3: Decrease in irrigation time and cost of major crops

Cropping Zones	Crops	Irrigations	With Laser Leveller-A			Without Laser Leveller-B			Difference in Cost (Rs. /acre) A-B	Signi-ficance
			No.	Time (Hours)	Total Cost	No.	Time (Hours)	Total Cost		
Rice-Wheat	Wheat	First	0.89	2.99	407	0.89	3.77	514	-107	0.004***
		Subsequent	1.05	2.46	394	1.05	3.25	521	-127	0.000***
		Total	1.94	-	801	1.94	-	1035	-234 (26.5%)	0.001***
	Rice	First	0.82	3.70	462	0.82	5.12	639	-177	0.000***
		Subsequent	23.29	2.25	7969	25.05	2.45	9357	-1388	0.0443**
		Total	24.11	-	8431	25.87	-	9996	-1565 (15.5%)	0.003***
Mixed Cropping	Wheat	First	0.95	2.88	415	0.95	4.04	582	-167	0.000***
		Subsequent	2.47	2.21	834	2.47	3.25	1225	-391	0.000***
		Total	3.42	-	1249	3.42	-	1807	-558 (28.9%)	0.000***
	Sugar-cane	First	0.67	2.60	264	0.67	3.80	386	-122	0.002***
		Subsequent	21.83	6.75	22454	24.33	9.50	35221	-12767	0.000***
		Total	22.50	-	22718	25.00	13.3	35607	-12889 (36.2%)	0.000***
	Cotton	First	0.50	3.00	600	0.50	3.90	780	-180	0.047**
		Subsequent	5.50	2.00	5000	5.50	3.00	6600	-1600	0.037**
		Total	6.00	-	5600	6.00	-	7380	-1780 (23.8%)	0.039**
	Maize	First	1.00	2.25	343	1.00	2.75	419	-76	0.084*
		Subsequent	12.00	1.75	3200	12.00	2.25	4114	-914	0.033**
		Total	13.00	-	3543	13.00	-	4533	-990 (21.8%)	0.036**

Note: ***, **, * indicate that differences are significant at 1, 5 and 10 percent levels.

Table 4: Changes in Land Preparation, Soil Fertility Improving & Total Costs (Rs./acre)

Cropping Zones	Crops	Cost Items	With Laser Levelling (A)	Without Laser Levelling (B)	Difference (A-B)	Difference (%)
Rice-Wheat	Wheat	Land Preparation	7574	4333	3241	74.8
		Fertilizers+ FYM	5816	6333	-517	-8.2
		Total Production Cost	44810	42089	2721	6.5
	Rice	Land Preparation	7574	4333	3241	74.8
		Fertilizers + FYM	10149	6333	3816	60.3
		Total Production Cost	58204	54099	4105	7.2
Mixed Cropping	Wheat	Land Preparation	9338	5091	4246	83.4
		Fertilizers+ FYM	5479	7481	-2002	-26.8
		Total Production Cost	43715	41783	1932	4.6
	Sugar-cane	Land Preparation	10561	4900	5661	115.5
		Fertilizers+ FYM	8434	8434	0	0
		Total Production Cost	100038	107370	-7332	-6.8
	Cotton	Land Preparation	5668	3268	2400	73.4
		Fertilizers+ FYM	9750	9750	0	0
		Total Production Cost	54015	52522	1493	2.8
	Maize	Land Preparation	10000	8700	1300	14.9
		Fertilizers+ FYM	18125	18125	0	0
		Total Production Cost	68864	68533	331	0.5

Table 5: Improvement in Crop Productivity (mounds/ acre)

Cropping Zones	Crops	With Laser Leveller (A)	Without Laser Leveller (B)	Difference (A-B)	Change (%)	Significance
Rice-Wheat	Wheat	38.09	33.55	4.54	13.5	0.012***
	Rice	41.00	35.00	6.00	17.1	0.001***
Mixed Cropping	Wheat	39.34	34.28	5.06	14.8	0.012**
	Sugarcane	748.00	712.50	35.50	5.0	0.340
	Cotton	29.00	24.50	4.50	18.4	0.005***
	Maize	92.50	84.00	8.50	10.1	0.067*

Note: ***, **, * indicate that differences are significant at 1, 5 and 10 percent levels.

levelling. Sample farmers growing rice crop obtained 6.00 mound per acre extra yield with use of laser land levelling. Similarly, in mixed cropping zone use of land laser levellers resulted into increase in productivity of sugarcane, cotton and maize crops by 35.50, 4.50 and 8.50 mounds per acre, respectively. Mean productivities of the selected crops with and without laser land levelling were found statically different, except for sugarcane cropping in the mixed cropping zone of Punjab province.

Table 6: Increase in Gross & Net Income (Rs. /acre)

Cropping Zones	Crops	Income Type	With Laser Leveller (A)	Without Laser Leveller (B)	Difference (A-B)	Significance
Rice-Wheat	Wheat	Gross	52065	45227	6838	0.000***
		Net	7255	3138	4117	0.000***
	Rice	Gross	68581	59410	9171	0.004***
		Net	10377	5311	5066	0.000***
Mixed Cropping	Wheat	Gross	52172	47652	4520	0.097*
		Net	8457	5869	2588	0.000***
	Sugarcane	Gross	129651	123500	6151	0.370
		Net	29613	16130	13483	0.000***
	Cotton	Gross	70600	59800	10800	0.013**
		Net	16585	7278	9307	0.000***
	Maize	Gross	86406	78650	7756	0.512
		Net	17542	10117	7425	0.000***

Note: ***, **, * indicate that differences are significant at 1, 5 and 10 percent levels.

Table 7: Increase in Returns to Investment

Cropping Zones	Crops	With Laser Leveller (A)	Without Laser Leveller (B)	Difference (A-B)	Rate of Return to Laser Levelling
Rice-Wheat	Wheat	1.16	1.07	0.09	3.35
	Rice	1.18	1.10	0.08	4.82
Mixed Cropping	Wheat	1.19	1.14	0.05	3.51
	Sugarcane	1.30	1.15	0.15	10.89
	Cotton	1.31	1.14	0.17	7.91
	Maize	1.25	1.15	0.11	14.49

With the use of land laser levelling, wheat farmers in rice -wheat and mixed cropping zones gained higher profitability than traditional farming by Rs. 4117 and Rs. 5795 per acre, respectively. Similarly, Tomar et al. (2020) also reported increased agricultural profitability in Madhya Pradesh, India by using the technology. Sample rice farmers obtained Rs. 5066 extra with the use of land laser leveller in rice-wheat zone. In mixed cropping zone, farmers gained extra profit by Rs. 13483, Rs. 9307 and Rs. 7425 in sugarcane, cotton and maize, respectively (Table 6).

The results showed that laser levelling technology users obtained higher gross margins as well as in received highest accounting profits for all major crops in both mixed cropping and rice-wheat zones. Net returns of land laser levelling for the selected crops are statistically different form crops grown without laser levelling (Table 7).

In wheat crop, increase in returns to investment in rice-wheat and mixed zone with the use of land laser leveller was Rs. 0.09 and Rs. 0.05 per acre, respectively. Rice growers achieved a gain in returns to investment by 0.08 with use of the technology. Similarly, for other major crops in mixed cropping zone, farmers gained an increase in returns to investment by 0.15, 0.17 and 0.11 for sugarcane, cotton and maize, respectively. Return to investment on land laser levelling ranged from 3.35 (wheat crop in rice-wheat zone) to 14.49 (maize crop in mixed zone). Thus, use of the technology results into considerable financial benefits for the farmers. However, the cost of a laser leveller is a big impediment to the adoption of this technology (Ahuja et al., 2016). It is believed that the effect of land laser levelling lasts for about four years (Aryal et al., 2015). Thus, potential financial benefits of land laser levelling are even more than found through the analysis of one calendar year.

Conclusions and Recommendations

It is obvious that land laser levelling is a resource-conserving technology, and its use results in saving of precious farm inputs like irrigation, labor and fertilizer etc. Presently, adoption of the technology is limited to large farmers due to expensive machines and lack of technical knowledge among land laser leveller operators. Moreover, inferior quality of land laser levellers and the very limited availability of repair and maintenance services restrain the adoption of the technology. Mostly the technology is adopted by educated, large-scale farmers owning tractors and financial strength. While farming experience does not matter much in the adoption. Due to limited availability of land laser levellers, rental rates are high which result into increase in cost production and hinder wide-scale adoption of the technology. While, use of land laser levellers results into improvement in productivity of crops. Farmers gain considerable financial returns by adopting the technology, mainly due to the saving of irrigation water and labor in all major crops and by decreasing the use of fertilizers in rice crop. Following are a few recommendations for enhancing the adoption of land laser levelling; effective implementation of subsidy programs along with a substantial increase in

scale; developing a cadre of agriculture service providers for the provision of technical know-how about effective use of machines along with repair and maintenance services at local level; and strict compliance to quality control on import of land laser levellers.

Authors' Contribution

NA conceptualized the research idea, designed the survey tool, performed statistical analysis, wrote the paper and supervised the research process. AH performed economic analysis of the data, tabulated the results, described main findings and incorporated reviewers' comments. WA participated in the field surveys, data editing and entry. AJ guided in data analysis. MZA contributed in the write up and revision of manuscript. SU reviewed literature and assisted in preparation of initial draft of the article. All authors read and approved the final draft before submission.

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