Economic Evaluation of Laser Land Levelling Technology in Punjab (India) A step towards sustainable development

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Abstract: Declining water table and degrading soil health are the major concerns for the current growth rate and sustainability of Indian agriculture. Agriculture in Punjab has a heavy requirement of water for irrigation purposes. The dominance of rice and wheat monoculture in cropping pattern of Punjab over the years has led to over exploitation of ground water, resulting in rapid decline of water table in the entire state (except south western part). So the present study was undertaken to study the impact of laser land leveling on resource use and returns from paddy crop. Multistage purposive cum random sampling was used for the selection of the study area.Further two blocks from district Amritsar were selected at second stage for the study purpose. At third stage two villages from each block were randomly selected..At the final stage 100 farmers were selected for the study purpose. In order to undertake the impact assessment task of this technology ,an equal number of adopters and non –adopters were selected from the same vicinity.

In all operations the time consumed was more in non-adopters category than in adopters category. It clearly shows the effect of Laser leveling technology. By comparing the variation in time spent of adopters over non-adopters major difference was in time spent on irrigation. In irrigation 63.80 hours were spent by adopters and 85.07 hours were spent by non-adopters in case of paddy. About 21 hours were more spent on irrigation by non-adopters in paddy crop. The total human labour-used was 44.23 hours per acre on adopter which was less as compared to non-adopter farms i.e. 47.25 hours per acre in paddy crop. The per acre labour-use on transplanting of paddy was 6.15 hours on laser leveled fields as compared to 6.45 hours on non-laser leveled fields. The per acre labour-use on plant protection was 7.25 hours laser leveled fields as compared to 8.85 hours on non-laser leveled fields. In all the farms operations more time was spent by non- adopters than by adopters. The difference was mainly due to laser leveling of the fields done by adopters farmers. The cost of laser land leveling incurred by the adopters of the technology was Rs 1025.75 per acre. The yield of paddy was 28.82 quintal per acre on laser leveled farms as compared to 26.98 quintal per acre on conventional farms. The variable cost per acre was less in the case of laser land leveled farms as compared to non-adopter farms. Due to higher productivity, the gross returns were also greater in case of adopter farms i.e. Rs.43518.2 as compared with non-adopter farms i.e. Rs.40739.8. The returns over variable cost were also higher in the case of laser land leveled fields i.e. Rs.32966.83 per acre, while in the case of non-adopter farms, the returns over variable cost worked out to be Rs.30034.38. Hence, with the use of laser land leveling technology, the profit increased by. Rs.2932.45 per acre in paddy crop.

To identify the factors affecting adoption, logit model was used in which adoption of laser land leveler was regressed with independent variables namely age, education, availability of laser leveler in the cooperative society, average time per irrigation, extension services in the village, less weed occurrence in the crop and yield of paddy crop of the farmers. The variables which were statistically significant have been used in backward step wise Regression model. Multivariate Logit Regression analysis was used to identify those variables which affect the respondents to use the laser leveler technology in wheat and paddy crop. In paddy crop the average time per irrigation and yield of crop influenced the use of laser level technology among adopters.

The main source of technology diffusion was fellow farmers and about 40 per cent of the farmers came to know and adopted the technology through learning from each other. The

progressive farmers of the area adopted the technology and encouraged others to follow. The co-operative societies also played an important role in the diffusion of the technology.

An opinion survey was also carried out regarding non adoption of the technology from sample farmers. About 45 per cent of non-adopters reported that the reason of their non-adoption was the high cost of laser land leveling. While 55 per cent of non-adopters reported that they were not fully aware of the technology, resulting in non-adoption of the technology. About 60 per cent of non-adopters reported that the reason of the non-adoption of the technology was their small and marginal holding.

Keywords: Laser Land Levelling Technology, logit model, farmers, crop

Introduction

Declining water table and degrading soil health are the major concerns for the current growth rate and sustainability of Indian agriculture (Kaur *et al*, 2012). Agriculture in Punjab has a heavy requirement of water for irrigation purposes. The dominance of rice and wheat monoculture in cropping pattern of Punjab over the years has led to over exploitation of ground water, resulting in rapid decline of water table in the entire state (except south western part). Most of the irrigation in Punjab is done through energized tubewells drawing underground water. Over the last 15 years, 75-80 percent of the water need of Punjab agriculture has been met through tubewells (Aggarwal *et al*., 2010). To draw more water (than what is returned back) to meet the irrigation needs of increasing area under paddy (Jeevandas *et al*., 2008), the number of tubewells increased from about 0.98 lakh in 1960-61 (Hira and Khera, 2000) to 13.83 lakh in 2014 (Dhiman *et al*., 2015) in Punjab.

Within a time span of 50 years (1960 to 2015), the area under rice cultivation in Punjab has increased phenomenally by over 10 times. This is one of the most startling changes in land use observed in agrarian history anywhere. This exponential increase has resulted in the ground water levels in Punjab going down drastically. As of 2011 out of total 138 blocks in Punjab, 110 are overexploited, four are critical, two are semi-critical and only 22 are safe. As per the central Ground water Board, Punjab has the highest stage of ground water development of 172 per cent amongst all the states in India. This is a scary index of the ground water status of Punjab. The ground water development stage of 100 percent indicates that ground water consumption is equal to ground water recharge; ground water development stage of above 100 percent indicates that the annual ground water consumption is more that the annual ground water consumption is more than the annual ground water recharge. A very high stage of ground water development of 172 per cent indicates that the annual water consumption in Punjab is very high compared to its annual recharge. An additional aspect of Punjab water vulnerability is that the ground water availability for future generation use for Punjab is not only lowest of all the states; it is, in fact negative (-14.83 billion cubic metre) as per the 2011 data.

The use of laser technology in the precision land leveling is of recent origin in India. It does not only minimize the cost of leveling but also ensures the desired degree of precision.. It has been noted that poor farm design and uneven fields are responsible for 30 per cent water losses (Asif *et al*., 2003). Precision land leveling (PLL) facilitated application efficiency through even distribution of water and increased water –use efficiency that resulted in uniform seed germination, better crop growth and higher crop yield (Jat *et al*., 2006). The scarcity of canal water supplies coupled with unfit ground water has compelled the farmers to utilize available water resources more wisely and efficiently. Under these circumstances, Precision Land Leveling (PLL) can help the farmers to utilize the scarce land and water resource more effectively and efficiently towards increased crop production (Abdullaev *et al*., 2007). It was estimated that around 25 to 30 per cent of irrigation water could be saved through this technique without having any adverse affect on the crop yield (Bhatt and Sharma, 2009).

Laser leveling is a technology that can grade an agricultural field to a flat surface by using a laser guided scraper. The benefits of laser leveling include improved crop yield, reduced labour time spent in weeding and in particular a reduction of up to 20-25 percent in irrigation water usage. So there is a need for developing efficient technique to conserve underground water by increasing irrigation efficiency (Singh *et al*., 2009). Laser assisted precision land leveling system is also likely to increase the cultivated area in the range of 3-6 percent (due to reduction in binds and channels in the field). Furthermore, on laser leveled fields, the performance of different crop establishment options such as of zero tillage, raised bed planting and surface seeding are known to have approved significantly (Jat *et al*., 2006). So keeping in view the scarcity of water the following study was taken in Amritsar district of Punjab with following objectives in view:

[1] To study the impact of laser land leveling technology on resource use and returns from paddy crop.
[2] To identify the factors affecting the adoption of laser land leveling technology and suggest measures to enhance its adoption.

Methodology

The study was mainly confined to Amritsar district of the Punjab state as groundwater is rapidly declining in this area was . Since the impact of laser land leveling technology is mainly being observed in the cultivation of paddy, the impact assessment study was restricted to the major crops that cover the study area i.e. wheat and paddy. Multi-stage Purposive cum random sampling technique was followed for the selection of the study area. Further, two blocks from selected district i.e. Attari block and Jandiala guru block from Amritsar district was selected randomly. At the third stage, two villages from each of these two blocks were randomly chosen. The farmers were selected using simple random sampling technique. In order to undertake impact assessment task of this technology, an equal number of non-adopters from the same vicinity were selected for the study purpose. Therefore, a total sample of 100 farmers (50 adopters plus 50 non-adopters) from two villages were selected for the study purpose.

The required information pertaining to the size of operational holding, human labour, seed, fertilizer, pesticides, insecticides, machinery, area, production, productivity of paddy and wheat crop were collected from the selected adopters and non-adopters.The data pertaining to the agricultural year 2016-17 were taken for the present study.

The data regarding the inputs were analyzed by using tabular method to show the extent their usuage in crop production. Simple statistical techniques such as averages percentages were used. Logit model was used to know the factors affecting adoption of laser leveler technology.

Results and Discussion

Input Use pattern

Laser leveling is a recent resource conservation technology initiative in India. It has the potential to change the way food is produced by enhancing resource use efficiency of critical inputs without any disturbing and harmful effects on the productive resilence of the ecosystem. For performing various operations in agriculture mainly two inputs are i.e machines and labour are used. For studying the effect of Laser leveling technology the time spent on various farm operations performed by machine or labour use was observed. The time spent by various operations in paddy crop by machine use and labor use by adopters of the technology and non-adopters of the technology is presented in the following tables.

Table 1 : Impact of Laser Land technology on labour used in Paddy crop (Hours per acre)

Variable	Labour employed adopter	Labour employed non-adopter	Change in total machine-use (Adopters over Non-adopters)
Laser leveler	2.35 (5.31)	0 (0)	**2.35**
Preparatory tillage	4.10 (9.26)	4.15 (8.78)	-0.05
Transplanting	6.15 (13.9)	6.45 (13.65)	-0.30

Irrigation	7.17 (16.21)	8.75 (18.51)	-1.58
Manure & Fertilizers	4.04 (9.13)	5.21 (11.02)	-1.17
Interculture/Weeding	2.81 (6.35)	3.85 (8.14)	-1.04
Plant Protection	7.25 (16.39)	8.85 (18.73)	-1.60
Harvesting	2.75 (6.21)	2.19 (4.63)	0.56
Transportation & Marketing	3.86 (8.72)	4.25 (8.99)	-0.39
Straw making	3.75 (8.47)	3.55 (7.51)	0.20
Total	44.23	47.25	-3.02

Note : Figures in the parenthesis indicate percentage to total.

Human labour, a vital input to conduct various on-farm and off-farm activities is generally provided by family members, permanent labour and casual labour. An attempt has been made to examine the human labour employment pattern in the cultivation of paddy on adopter and non-adopter farms through tabular analysis.

It was observed from the Table 1 that on adopter farms the total human labour-used was 44.23 hours per acre on adopter which was less as compared to non-adopter farms i.e. 47.25 hours per acre. The per acre labour-use on transplanting of paddy was 6.15 hours on laser leveled fields as compared to 6.45 hours on non-laser leveled fields. The per acre labour-use on plant protection was 7.25 hours on laser leveled fields as compared to 8.85 hours on non-laser leveled fields. In all the farms operations more time was spent by non-adopters than by adopters. The difference is mainly due to laser leveling of the fields done by adopter fa**rmers.**

Table 2 : Impact of laser land technology on machine use in Paddy crop (Hours per acre)

Particular	Adopter	Non-adopter	Change in total machine-use (Adopters over Non-adopters)
Laser leveler	2.40 (3.33)	0 (0)	2.40
Preparatory tillage	3.09 (4.28)	3.42 (3.75)	-0.33
Irrigation	63.80 (88.53)	85.07 (93.39)	-21.27
Harvesting	1.37 (1.90)	1.29 (1.43)	0.08
Transportation & Marketing	1.40 (1.96)	1.31 (1.43)	0.09
Total	72.06	91.06	-19.0

Note : Figures in the parenthesis indicate percentage to total.

Impact of laser land technology on machine use in Paddy crop

It was observed from the table 2 that the per acre machine use in paddy cultivation on laser leveled farms was 72.06 hours which were less as compared to 91.06 hours on non- laser leveled farms. Tractor-use accounted for the major use amongst the machine use pattern. Most of the sample farmers had their own tractor and other major tractor driven tools and implements. Due to the unevenness of the land surface, the tractor used for the operation of preparatory tillage was relatively more in non-adopter farms i.e. 3.42 hours per acre as compared to adopter farms i.e. 3.09 hours per acre respectively.

In all operations the time consumed was more in non-adopters category than in adopters category. It clearly shows the effect of laser leveling in adopters field. By comparing the variation in time spent of adopters over non-adopters major difference was in time spent on irrigation. In irrigation 63.80 hours were spent by adopters and 85.07 hours were spent by non-adopters in case of paddy. About 21 hours were more spent on irrigation by non-adopters in paddy crop whereas 0.33 hours were more spent in tillage, 0.08 more hours in harvesting. In total 19 hours per acre were more spent by non-adopters in case of paddy crop.

Table 3: Impact of laser leveler technology on cost and returns of paddy cultivation (Rs per acre)

Crop paddy	Adopters	Non-Adopters
Seed	321.51	351.25
Cost of preparatory tillage	1003.45	1300.45
Cost of laser leveling	1025.75	0
Transplanting Cost	2443.21	2515.22
Plant protection chemical	1225.01	1575.29
Urea	725.70	950.25
DAP (kg)	565.42	580.65
MOP (kg)	0	0
Micro-nutuent (kg)	580.25	615.25
Machine Charge	0	0
Causal labour payment (hours)	775.21	925.75
Harvesting cost	1180.35	1215.85
Transportation cost	505.10	495.25
Marketing cost	200.41	180.21
Total variable cost	10551.37	10705.42
Yield (quintal)	28.82 (43518.2)	26.98 (40739.8)
Return over variable cost	32966.83	30034.38

Impact of laser leveler technology on cost and returns of paddy cultivation

The input-use in physical as well as value terms and the benefits realized per acre of paddy on laser and non-laser leveled farms have been discussed in Table 3. The cost of laser land leveling incurred by the adopters of the technology was Rs 1025.75 per acre. The hiring of laser leveler is done on per hour basis (hiring rate ranged between Rs 500 per hour to Rs 600 per hour). Discounted cash flow analysis was employed and the cost on laser land leveling was divided by two, as this cost is borne for two years and sample farmers told that this cost will be borne by them in third year i.e. again laser leveling is done on the same farm in the third year. So, the cost of laser land leveling incurred by the adopters annually was Rs1025.75 per acre.

Cost of preparatory tillage includes the cost of tractor oil consumption on cultivating, levelling and puddling the field if the farmer owned the tractor otherwise hired payment made by the farmer for preparing the field if the tractor was the hired one. The cost of tillage was i.e. Rs 1003.45 per acre on laser leveled farms as compared to Rs 1300.45 per acre on non-laser leveled farm.

As the electricity supply is totally free in Punjab state, the irrigation charges includes the diesel/oil consumption for irrigating the paddy crop. The diesel/oil consumed for irrigation purpose was very less on the farms who adopted the technology as leveling improves the water-use efficiency and the same field can be irrigated in lesser time than the non-leveled one. Due to less occurrence of the weeds on the laser land leveler farms the expenditure made on human labour hired for weeding per acre was less i.e. Rs.775.21 as compared to Rs.925.75 in case of non-adopter farms. The yield of paddy was 28.82 quintal per acre on laser leveled farms as compared to 26.98 quintal per acre on conventional farms. The variable cost per acre was less in the case of laser land leveled farms as compared to non-adopter farms.

Due to higher productivity, the gross returns were also greater in case of adopter farms i.e. Rs.43518.2 as compared with non-adopter farms i.e. Rs.40739.8. The returns over variable cost were also higher in the case of laser land leveled fields i.e. Rs.32966.83 per acre, while in the case of non-adopter farms, the returns over variable cost worked out to be Rs.30034.38. Hence, with the use of laser land leveling technology, the profit increased i.e. Rs.2932.45 per acre.

Factors affecting adoption of laser level Technology (Multivariate Logistic Regression Analysis)

To identify the factors affecting adoption, logit model was used in which adoption of laser land leveler was regressed with independent variables namely age, education, availability of laser leveler in the cooperative society, average time per irrigation, extension services in the village, less weed occurrence in the crop and yield of paddy and wheat crop of the farmers. The variables which are statistically significant have been used in backward step wise Regression model. Multivariate Logit Regression analysis was used to identify those variables which affect the respondents to use the laser leveler technology in paddy crop. Analysis of results of final backward stepwise multivariate analysis model has been discussed in following tables.

Table 4: Backward Step wise Multivariate Logistic Regression (Paddy)

Variables	1	2	3	4	5	6
(Intercept)	-425.7458 ^{NS} (0.2)	-195.55792 ^{NS} (0.0)	-192.31431* (0.0)	-194.13478* (0.0)	-170.68435* (0.0)	-129.674** (0.0)
Age	-0.3642 ^{NS} (0.2)	-0.14355 ^{NS} (0.1)	-0.14170 ^{NS} (0.1)	-0.13821 ^{NS} (0.1)	-0.10500 ^{NS} (0.1)	
Education	-0.5060 ^{NS} (0.4)	-0.19542 ^{NS} (0.4)	-0.19008 ^{NS} (0.4)	-0.16748 ^{NS} (0.4)		
Availability & laser Leveling	12.1029 ^{NS} (0.6)					
Average time per irrigation	-8.3198 ^{NS} (0.2)	-5.15810 * (0.0)	-0.05468* (0.0)	-4.92555* (0.0)	-4.35009* (0.0)	-4.567** (0.0)
Extension service	-3.5921 ^{NS} (0.3)	-0.14043 ^{NS} (0.9)				
Less weed occurrence	12.3544 ^{NS} (0.6)	0.38080 ^{NS} (0.8)	0.33282 ^{NS} (0.8)			
Yield of crop	17.9390 ^{NS} (0.2)	8.71652* (0.0)	8.56750* (0.0)	8.59584* (0.0)	7.47989** (0.0)	5.873** (0.0)
AIC	29.722	32.09	30.097	28.149	26.802	27.632

Note : Figure in parenthesis indicate probability

* refers to 5 per cent level of significant ** refers to 1 per cent level of significant *** refers to 0.1 percent level of significant

NS refers to not significant

In case of paddy crop in step one no variable was found significantly affecting the decision to adopt the laser leveling technology among sample farmers (Table 4). In first step, all the variables were found to be insignificant and AIC (Akaikes Information criteria) was 29.72. In second step least significant variable factor from the logit equation was excluded i.e availability of laser leveler in the cooperative society. At the second step two variables were found to be significant i.e average time taken for each irrigation and yield of the crop and AIC was 30.09. In next step one more least significant variable was eliminated i.e less weed occurrence and AIC was 28.14. In the final step education of the respondents was eliminated from the logit equation and AIC was 26.80. Elimination of variables from the logit equation was stopped at this point as AIC starts increasing. So the two main factors which affected the adoption of laser leveler technology in paddy crop was average time per irrigation for paddy crop and yield of paddy crop. Average time per irrigation was significant at five percent level of significance and yield of crop was significant at one percent level of significance. These two factors were considered to be most significant factors for the adoption of laser leveling technology.

Opinion survey of the sample farmers

No doubt laser land leveling technology is a resource conservative technology and farmers in Punjab are adopting this technology very fast. To make the adoption of this technology still faster, there is a need to identify the constraints inhibiting the adoption of this technology and solutions thereof. So an opinion survey was carried out

Diffusion pattern of the laser land leveling technology

The respondents were imparted the knowledge of the laser land leveling technology by various agencies like state governments, agricultural departments, co-operative societies, krishi vigyan kendars, fellow farmers, etc. The main source of technology diffusion was fellow farmers and about 40 per cent of the farmers came to know and adopted the technology through learning from each other. The progressive farmers of the area adopted the technology and encouraged others to follow. The co-operative societies also played an important role in the diffusion of the technology; their share was about 16 per cent (Table 5). Around 16.5 farmers came to know about the technology from Kisan mela and 7.5 percent farmers learned about technology from other sources such as Government or agriculture department, seminars, campaigns etc.

Table 5: Source of inspiration for adopting laser land leveling technology by the sample farms

Sources	Per cent Response
Friends/Relatives	20
Fellow farmer	40
Co-operative society	16
Kisan mela	16.5
Other sources*	7.5

Note: Other sources include Government/agriculture departments, seminars, campaigns etc.

Qualitative perceptions regarding the laser land leveling technology

The qualitative perceptions of the adopters regarding the laser land leveling technology have been presented in Table6. The perusal of the table revealed that about 85 per cent adopters perceived yield enhancement with the use of laser land leveling technology. About 95 per cent of the adopters agreed that the technology reduces the irrigation cost as the need for using generators and diesel engines as an alternative source of electricity is reduced. As the entire land is leveled and water spreads evenly on entire surface area, all the adopters (100 per cent) were of the view that the adoption of this technology reduces water requirement of the crop.

Table 6: Farmers perceptions regarding the impact of laser land leveling technology by the sample farms (Multiple Response)

Perceived Impact	Per cent Response
Yield enhancement	85
Reduce irrigation cost	95
Reduction in water requirement	100
Low fertilizer requirement	50
Less weed occurrence	65
Enhancement of soil compaction	42.5

Note: The responses correspond to the adopters of the technology

About 50 per cent of adopters agreed that the adoption of technology reduced the fertilizer requirement due to the uniform distribution of water over the soil surface which enhances the regulated uptake of nutrients by the crop plants. About the weed population on the laser land leveler farms, about 65 per cent of the adopters agreed that weed occurrence reduced because of the uniform distribution of irrigation water and compactness of soil. About 42.5 per cent of the adopters reported that laser land leveling technology increased the soil compactness which further enhanced the water storage capacity of the soil.

Constraints/Problem in adoption of laser land leveling technology

The information presented in Table 7 brings out that about 65 per cent of the non-adopters reported the problem of non-availability of the laser land leveler in the peak season.

Table 7: Constraints/Problems faced by non-adopters of laser land leveling technology in Punjab (Multiple Responses)

Constraints	Per cent Response
Non-availability of laser land leveller	65
High cost of levelling	45
Small size of holding	60
Lack of awareness	55

Note: The responses correspond to the non-adopters of technology

About 45 per cent of non-adopters reported that the reason of their non-adoption was the high cost of laser land leveling. While 55 per cent of non-adopters reported that they were not fully aware of the technology, resulting in non-adoption of the technology. About 60 per cent of non-adopters reported that the reason of the non-adoption of the technology was their small and marginal holding.

Conclusions

The study concluded that adoption of Laser level technology decreased the use of machine and labour in paddy crop. The hours per acre spent by machine and labour in different farms was less in laser leveled farms. The number of irrigation in paddy was also less in laser leveled farms.Due to laser leveling of farms, the costs were less and returns was more in Paddy crop. The maximum saving was on numbers of irrigations per acre on laser leveled farms.The main factor influencing the adoption of laser leveling was number of irrigation in paddy crop and yield of paddy crop. For maximum use of laser level technology in the state it was suggested that more laser leveler should be available at co-operative societies and at less cost. Farmers should be made more aware about the water crisis of the Punjab. More extension services should be given to the non-adopters for adopting this water saving technology.

References

[1] Abdullaev I, Hasan M U and Jumaboev K (2007) Water saving and economic impacts of land leveling: the case study of cotton production in Tajikistan. *Irrig Drainage Syst* **21**:251-263.

[2] Aggarwal R, Kaur S, and Singh, A (2010) Assessment of saving in the water resources through precision land leveling in Punjab. *Journal of Soil and Water Conservation.* **9**

[3] Asif M, Ahmed M, Gafool A, Asiam Z (2003) Wheat productivity and Water. Use Efficiency by Traditional and Laser land- leveling Techniques. On line *J. Biol. Sci*. **3**(2):141-146 (3):182-185.

[4] Dhiman J, Dhiman J S, Kaur A, Aggarwal R and Dhiman M (2015) New approaches and strategies for irrigation water management. *Indian Journal of Economics and Development* **12**(1):1-14.

[5] Hira G S, and Khera K L (2000) Water resource management in Punjab under rice –wheat production system. Research Bulletin No:2. Department of Soils, Punjab, Agricultural University, Ludhiana

[6] Jat M L, Chandana P, Gupta R, Sharma S K and Gill M A (2006) Laser Land Leveling: A precursor for resource conservation. Rice-Wheat Consortium Technical Bulletin Series 7. PP 48. Rice-Wheat consortium for the Indo-Gangetic Plains, New Delhi, India.

[7] Jeevandas A, Singh R P and Kumar R (2008) Concerns of groundwater depletion and irrigation efficiency in Punjab agriculture: A micro-level study. *Agri Econ Res Rev* **21**:191-199.

[8] Kaur B, Singh S, Garg B R, Singh J M and Singh J (2012) Enhancing water productivity through on farm resource conservation technology in Punjab agriculture. *Agri Econ Res Rev* **25**:93-99.

[9] Singh T, Gill M S, Sidhu H S, Singh S and Sidhu A S (2009) Effect of laser land leveling on water productivity and yield of rice-wheat cropping system. *Ind J Ecol* **36**(1):95-97.