Indian Journal of Agricultural Sciences **81** (7): 657–8, July 2011

Economic efficiency of rice (*Oryza sativa*) cultivation in northern urban India

MAHENDRA SINGH[1] and PURAN CHAND[2]

Indian Agricultural Research Institute, New Delhi 110 012

Received: 15 January 2010; Revised accepted: 10 May 2011

Key words: Data envelopment analysis, Economic efficiency, Rice, Sewage irrigation

The use of sewage water for irrigation has increased due to rapid urbanization and consequent generation of sewage water. The use of sewage water for irrigation offers several advantages such as reduction in the fertilizer requirement, higher productivity and net income vis-à-vis irrigation with fresh water (FAO 2010). Rattan *et al.* (2005) reported that the irrigation with sewage water for more than 20 years resulted in significant build-up of Zn (208%), Cu (170%), Fe (170%), Ni (63%) and Pb (29%) over the adjacent tubewell water irrigated soils. Deshmukh *et al.* (2010) reported that groundwater under sewage-irrigated fields of the west Delhi was found to be unfit for consumption for human and animals due to contamination of dreaded micro-organisms.

The concept of economic efficiency consists of two components: technical efficiency and allocative efficiency. Technical efficiency is defined as the capacity of an economic unit to produce the maximum possible output from a given bundle of inputs and technology. The allocative efficiency is defined as the ability of an economic unit to equate its specific marginal product with the marginal cost.

Jeevandas *et al.* (2008) used data envelopment analysis (DEA) to measure technical efficiency and reported that 57% and 65% technical efficiency in tubewell irrigated and tubewell + canal irrigated farm, respectively in rice cultivation in Punjab. Wang (2010) estimated technical efficiency for irrigation water by using DEA and found 62% efficiency in wheat cultivation in China. Although there are several studies relating to measurement of economic efficiency of field crops, however, there is dearth of sewage water-use efficiency in rice *(Oryza sativa* L.) crop. In the present study, an attempt has been made to measure the technical, allocative and economic efficiency of the field with different distance from the sewage canal, cultivated rice by using sewage water in west Delhi.

For estimating the efficiency, primary data collected from sampled farmers for 2007–08, which were grouped into two categories namely small (up to 2 ha) and medium farmers (2–4 ha), belong to the Ranhola and Bakarwala villages. They were using sewage water for irrigation purpose, supplied from Keshopur sewage treatment plant. The inputs were taken on per hectare basis and included seed, fertilizer, manure, human labour, machine labour and irrigation.

The input-based model was used with the assumption that the farmers have the control over inputs in a short run than outputs. The constant returns to scale (CRS), input-oriented of data envelopment analysis (DEA), methodology developed by Coelli *et al.* (2005) was used to measure the technical efficiency (TE) of the farms as follows:

$$\text{Min}_{\theta,\lambda}\ \theta,$$
$$\text{Subject to: } -q_i + Q\lambda \geq 0,$$
$$\theta x_i - X\lambda \geq 0,$$
$$\lambda \geq 0,$$

where, θ is a scalar and λ is a I×1 vector of constants. The estimated value of θ is the efficiency score for the ith farm. It satisfies θ ≥ 1 with a value of 1 indicating a technically efficient farm and if TE is < 1, the farm is technically inefficient.

The allocative efficiency (AE) index was estimated by using the input-oriented model for cost minimization as follows:

$$\text{Min}_{\lambda,x_i^*}\ w_i' x_i^*,$$
$$\text{Subject to: } -q_i + Q\lambda \geq 0,$$
$$x_i^* - X\lambda \geq 0,$$
$$\lambda \geq 0,$$

where, w_i is a N ×1 vector of input prices for the ith farm and x_i^* is the cost minimizing vector of input quantities for the ith farm, given the input prices w_i and output levels q_i.

The total cost efficiency (CE) or economic efficiency (EE) of the ith farm was calculated as follows:

$$\text{CE or EE} = w_i' x_i^* / w_i' x_i.$$

The EE is the ratio of minimum cost to observed cost for the ith farm.

Hence, AE is then calculated as: AE=EE/TE or EE = AE × TE

Thus, AE is the economic efficiency after taking out the effect of technical inefficiency. Therefore, AE is the ratio of

[1]Technical Officer (T7/8) (e mail: mahendrasingh582005 @yahoo.co.in), [2]Ex-Principal Scientist (e mail: chand_puran @yahoo.co.in), Division of Agricultural Economics

Table 1 Technical, allocative and economic efficiency of rice growing farms in Delhi

Village	Farmer's category	Distance of the parcel from sewage canal (km)	Techni-cal	Alloca-tive	Econo-mic
Bakarwala	Medium	0.000	0.860	0.854	0.734
	Medium	0.500	0.896	0.850	0.762
	Medium	0.500	1.000	1.000	1.000
	Medium	1.000	1.000	0.925	0.925
	Medium	1.000	1.000	0.940	0.940
	Medium	1.000	1.000	1.000	1.000
	Small	0.000	0.803	0.801	0.643
	Small	0.000	0.914	0.905	0.827
	Small	0.000	1.000	1.000	1.000
	Small	0.000	0.961	0.954	0.917
	Small	0.500	0.750	0.714	0.536
	Small	0.500	0.879	0.821	0.722
	Small	0.500	0.957	0.957	0.916
	Small	1.000	0.993	0.977	0.970
	Small	1.000	1.000	0.952	0.952
Ranhola	Medium	0.000	0.206	0.202	0.042
	Medium	0.000	0.258	0.253	0.065
	Medium	0.500	0.459	0.453	0.208
	Medium	1.000	0.561	0.388	0.218
	Medium	1.000	0.680	0.576	0.392
	Medium	1.000	0.664	0.656	0.436
	Small	0.000	0.050	0.050	0.003
	Small	0.000	0.100	0.100	0.010
	Small	0.000	0.150	0.150	0.023
	Small	0.500	0.305	0.302	0.092
	Small	0.500	0.354	0.351	0.124
	Small	0.500	0.403	0.401	0.162
	Small	0.500	0.516	0.506	0.261
	Small	1.000	0.740	0.493	0.365
	Small	1.000	0.617	0.606	0.374
Average			0.691	0.658	0.538

the cost from the hypothetical technical efficient farm to minimum cost obtained by allocation of resources in the right way.

The technical, allocative and economic efficiency of rice-growing farms using sewage water for irrigation in Delhi is presented in Table1. The DEA analysis showed the average technical efficiency of the all category of rice farmers has found 0.691. It implies that rice farmers could increase their production by as much as 31% by using same amount of inputs more efficiently.

The mean of allocative efficiency was found 0.658, which implies that 34% of inputs cost could be saved by using rational combination of the inputs. The economic efficiency was showed 0.538 which implies that 46% rice farms were inefficient in rice production in Delhi. It implies that though the rice farmers were relatively technically efficient, but they were allocatively and economically less efficient due to higher input cost and use of irrational combination of inputs in rice production. Results also showed that distant field from sewage canal found relatively more efficient than near to sewage canal across the category of farmers and villages. It might be due to waterlogging and inefficient use of sewage water in parcels nearer to sewage canal for rice cultivation.

SUMMARY

This study revealed that the mean of technical, allocative and economic efficiency was 69%, 66% and 54% respectively. Although Delhi farmers were observed to be relatively technically efficient in rice production but their allocative and economic efficiencies were comparatively lesser due to higher inputs cost (except irrigation water) and use of irrational combination of inputs. The study also showed positive relationship between distance of the field from sewage canal and economic efficiency in rice cultivation across the category of farmers and villages. The study indicates that efficient and optimum use of inputs has become necessary to sustainable cultivation of rice in Delhi.

ACKNOWLEDGEMENT

Financial support provided by the Indian Agricultural Research Institute, New Delhi to carry out this study is gratefully acknowledged.

REFERENCES

Coelli T J, Prasada Rao D S, O'Donnell C J and Battese G E. 2005. *An Introduction to Efficiency and Productivity Analysis*, 2nd edn, 349 pp. Springer, New York.

Deshmukh S K, Singh A K, Datta S P and Annapurna K. 2011. Impact of long-term wastewater application on microbiological properties of vadose zone. *Environmental Monitoring and Assessment* **175**: 601–12.

FAO. 2010. The wealth of waste: The economics of wastewater use in agriculture. *FAO Water Report No. 35*, accessed on line:http://www.fao.org/docrep/012/1629e/1629e.pdf

Jeevandas A, Singh R P and Kumar R. 2008. Concerns of groundwater depletion and irrigation efficiency in Punjab agriculture: A micro-level study. *Agricultural Economics Research Review* **21** (2) : 191–9.

Rattan R K, Datta S P, Chhonka P K and Singh A K. 2005. *Heavy Metal Contamination Through Sewage Irrigation in Peri-urban Areas of National Capital / Territory of Delhi*, 51pp . Division of Soil Science and Agricultural Chemistry. Indian Agricultural Research Institute, New Delhi

Wang xue-yuan. 2010. Irrigation water use efficiency of farmers and its determinants: Evidence from China. *Agricultural Sciences in China* **9** (9) : 1326–37.