International Scholars Journals

International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 6 (2), pp. 938-948, February, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Technical and economic efficiency of resource use in wetland rice cultivation

Md. Mokidul Islam[1] and D.C. Kalita[2]

[1]Subject Matter Specialist (Agronomy), KVK, Tura, ICAR Research Complex for NEH Region Sangsanggre, P.O.: Dobasipara, West Garo Hills (Meghalaya), India.
[2]Associate Professor, Department of Rural Development and Agricultural Production North-Eastern Hill University, Tura Campus, Tura (Meghalaya), India.

Accepted 12 January, 2014

Abstract

The study was undertaken to estimate the resource use efficiency of wetland rice cultivation in West Garo Hills district of Meghalaya during the cropping season of 2010-11. Data for the study was collected from 120 wetland rice farmers through simple random sampling procedure with at least 20 farmers from each CD Block covering 20 villages including at least six farmers from each village. The Cobb-Douglas production function (monetary value) was used to measure the resource use efficiency of wetland rice farmers. Findings revealed that the wetland rice farmers were technically inefficient in the use of farm resources. The implication of the study was that technical efficiency in wetland rice production in West Garo Hills district of Meghalaya could be increased through better use of land, fertilizer and improved seeds. However, the values of the MPP showed that the farmers were technically more efficient in the use of land than all the resources for higher productivity of wetland rice. This implies that land, fertilizer, FYM/vermicompost and irrigation were under-utilized (>1) while all other inputs were over- utilized (<1). The adjustment in the MVPs for optimal resource use (% divergence) indicated that for optimal allocation of resources required about 33.87, 84.81, 83.18, 141.35, 166.23, 357.03, 190.52, 27.74, 135.32, 118.91 % increase in land, fertilizers, FYM/vermicompost, weedicides, pesticides, fencing, power tiller, irrigation, machinery/implements and marketing, respectively while seeds, human labour and bullock labour were over utilized which required 52.21, 89.11, 27.18 % reduction for optimal use in wetland rice production.

Key words: Technical and economical efficiency, resource use, wetland, cobb-douglas production function.

INTRODUCTION

Meghalaya is basically an agricultural state with about 80% of its total population depending entirely on agriculture for their livelihood. Rice is the staple food of the people of Meghalaya. The state comprises seven district viz., East Khasi Hills, West Khasi Hills, Ri-Bhoi, Jaintia Hills, East Garo Hills, West Garo Hills and South Garo Hills having the total rice area of about 108 thousand hectares with production of 191 thousand tonnes and productivity of 1769 kg/ha which was at par with the average productivity of NE states but lower than the national average. The West Garo Hills district of Meghalaya covers about 38.76 thousand hectare area

*Corresponding authors e-mail: mislam01d@yahoo.co.in

under total rice with the production of 69.32 thousand metric tonnes and productivity of 2323 kg/ha which might be due to higher production of spring season rice. However, out of total rice area, the wetland rice covers about 17.35 thousand hectare with the production of 30.0 thousand metric tonnes and productivity of 1729 kg/ha which is lower than the national average (2177kg/ha).

It is important to understand the performance of any new technology in the context of farmer's realities, which are always more complicated and more diversified than on any research station. It is difficult to estimate the efficiency of the farmers without the knowledge of the conditions under which the production is performed. To achieve maximum profit in a resource-constrained production environment, the farmers have to be price-responsive. The efficiency associated with allocation of inputs according to the prevailing market price is called allocative efficiency of the farmers. Even if, the farmers are allocatively efficient, they may not be realizing the technically feasible maximum production due to inefficient management of the resources. In such cases, a comparison of output in relation to the level of inputs-used will reveal the true picture of efficiency. This is referred to as technical efficiency. Efficiency is an important concept in production economics when resources are constrained and opportunities of adopting better technologies are competitive (Gaddi *et al*., 2002). Efficiency studies help in understanding the current performance and opportunities to improve the production performance of the crops under consideration. Efficiency studies have showed that it is possible to raise the productivity of the crop without actually raising the input application (Ali and Choudhury, 1991; Umesh and Bisalaiah , 1991 and Gaddi *et al.,* 2002). The corrective steps undertaken to mitigate the reasons for the low efficiency of the farmers will help in long-term to achieve higher productivity. Keeping in view of the above facts, the present study was undertaken to estimate the resource use efficiency of wetland rice cultivation in West Garo Hills district of Meghalaya.

METHODOLOGY

The study was undertaken in different villages of West Garo Hills district of Meghalaya. The data for the study was drawn from primary sources with the help of pre-tested structured schedules. The primary data were collected from 120 selected wetland rice farmers through simple random sampling procedure with at least 20 farmers from each CD Block covering 20 villages including at least six farmers from each village during the crop season 2010-11. The samples were stratified into three size groups by using cumulative frequency rule (Kalita, 1996) following proportional allocation method of sampling on the basis of land holding of wetland rice farmers. The distribution of selected wetland rice farmers across various size groups were 0 to 1.20ha in group I having 46 farmers, 1.20 to 2.40 ha in group II having 44 farmers and above 2.40 ha having 30 farmers. The farm family size, level of education, working force and its occupational pattern, land resources, land use pattern, cropping pattern of all the three size groups of sample farmers were estimated. The resource use efficiency was estimated by using the Cobb-Douglas production function.

Analysis of resource use efficiency

The Cobb-Douglas production function (monetary value) was used to measure the resource use efficiency of wetland rice farmers of West Garo Hills district of Meghalaya. The general form of Cobb-Douglas production function is given below:

Cobb-Douglas P.F $\mathbf{Y = a_0 \, x_i^{a_1}}$

Where, Y= Level of output

$\mathbf{x_i}$ = level of inputs

$\mathbf{a_0, a_1}$= constant represent efficiency parameter and the production elasticities of respective input variables.

Input use efficiency was examined using equimarginal principle which was explained by allocative efficiency and measured by the following ratio.

$$\text{Allocative efficiency} = \frac{MVP}{MFC}$$

Where, **MVP** = Marginal value product

MFC = Marginal factor cost (price of input)

MVP= $\mathbf{MPP_{xi} . P_o}$

$\mathbf{P_o}$ **=** price of output (rice)

MPP = the marginal physical product of resource input used

$$\mathbf{MPP_{xi}} = \mathbf{bxi} \, . \, \frac{Y}{\mathbf{Xi}}$$

Where,

bxi = Elasticity co-efficient of xi[th] independent variable

Y= Geometric mean of output

Xi = Geometric mean of x_i inputs

bxi was estimated from Cobb-Douglas production function using Ordinary Least Square (OSL) approach after converting it into loglinear form. The estimable form of the equation is given below:

$$\text{Ln } Y = \text{Ln } a + b_1 \text{ Ln } x_1 + b_2 \text{ Ln } x_2 + \ldots\ldots\ldots\ldots + b_n \text{Ln } x_n$$

Where, **a**=intercept

$b_1 \ldots\ldots\ldots b_n$=parameter to be estimated

$x_1 \ldots\ldots\ldots x_n$ = inputs

Determination of Economic Efficiency of Resource Use

The following ratio was used to estimate the relative efficiency of resource use (r)

$$r = MVP/MFC$$

Where,

MFC = cost of one unit of a particular resource

MVP = value added to wetland rice output due to the use of an additional unit of input calculated by multiplying the $MPP_{xi} \times P_o$

Decision rule: If r = 1, resource is efficiently utilized

r > 1, resource is underutilized while

r < 1, resource is over utilized

Economic optimum was taken place where MVP = MFC. If r is not equal to 1, it is suggested that resource are not efficiently utilized. Adjustments could be therefore, be made in the quantity of input used and costs in the production process to restore r = 1.

Determination of Technical Efficiency of Resource Use

The elasticity of production which is the percentage of change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of input (Farrel, 1957). This is given as:

$$E_p = MPP/APP$$

Where, E_P = Elasticity of production

MPP = Marginal physical product (change of output)

APP = Average physical product (change of input)

If, $\sum E_p = 1$: constant return to scale

$\sum E_p < 1$: decreasing return to scale

$\sum E_p > 1$: increasing return to scale

RESULTS AND DISCUSSION

Socio-economic profile of sample farmers

The results of the study obtained through analysis of the data collected from the sample farmers on the socio-economic variables such as family size and level of education, working force and its occupational pattern, land resource and its utilization pattern, cropping pattern, input use efficiencies of wetland rice cultivation in the district.

Farm family size and level of education

The result showed that the average family size of wetland rice farmers were 5.87, 6.20 and 7.40 in size group I, II and III, respectively. The total population was 765 with an average family size of 6.49. The education level of the wetland rice farmers observed that the proportion of literates increased with the increase in size of the farm (Table 1). Further, the proportion of male literates was higher than the female literates in all the three size groups. The finding indicated that the rate of literacy was higher than the district average (male 57 %, female 44% and average 50.7%) in the study area. But, both the male and female literacy did not show much variation across the size of the wetland rice farmers. However, they showed the positive relationship with farm size and primary education which was the most prevalent level of education in the sample population of the study area.

Farm family working force and its occupational pattern

It was observed that the male and female working force was 28.37 and 25.10 %, respectively out of total working force (53.56%) in the study area. Proportion of working force increased with the increase in farm size, even though, the bigger farm size (group- III) accounted for greater number of working force compared to their lower counterparts. The results indicated that about 40.10 and 36.92 % of the total working force had agriculture as primary occupation (Table 2). This was followed by business, service and others in the sample population of wetland rice farmers. Among the different size groups, agriculture was also found to be the dominated form of primary occupation. Even then, agriculture was relatively more important for the group I and group III compared to group II farmers. The occupational patter also indicated that 22.49 and 22.98 % for male and female, respectively of total working force had agriculture as a secondary occupation of the sample population which was followed by others including wage labourers i.e. others was relatively more important in group I, business in group II and agriculture in group III as secondary occupation of the sample population. Hence, the results of the occupational pattern of the working force revealed that agriculture particularly wetland rice cultivation was considered as the primary and secondary occupation of the sample population in the study area.

Table 1. Farm family size and level of education of sample population of wetland rice farmers of various size groups.

Size group (ha)	Sample size	Avg. family size of sample population	Total sample population	Illiterate			Literate														
							Primary			High			PU/HS			Graduate & above			Total Literates		
				M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Group-I	46	5.87	270	69	72	141	48	46	94	20	11	31	3	1	4	0	0	0	70	61	131
Per cent			100	25.56	26.67	52.22	17.78	17.04	34.81	7.41	4.07	11.48	1.11	0.37	1.48	0.00	0.00	0.00	25.93	22.59	48.52
Group-II	44	6.20	273	56	63	118	32	32	64	33	25	58	19	5	24	7	2	9	91	64	155
Per cent			100	20.51	23.08	43.22	11.72	11.72	23.44	12.09	9.16	21.25	6.96	1.83	8.79	2.56	0.73	3.30	33.33	23.44	56.78
Group-III	30	7.40	222	40	49	89	29	27	56	27	23	50	14	10	24	2	1	3	72	61	133
Per cent			100	18.02	22.07	40.09	13.06	12.16	25.23	12.16	10.36	22.52	6.31	4.50	10.81	0.90	0.45	1.35	32.43	27.48	59.91
Total	**120**	**6.49**	**765**	**165**	**184**	**348**	**109**	**105**	**214**	**80**	**59**	**139**	**36**	**16**	**52**	**9**	**3**	**12**	**233**	**186**	**419**
Per cent			100	21.57	24.05	45.49	14.25	13.73	27.97	10.46	7.71	18.17	4.71	2.09	6.80	1.18	0.39	1.57	30.46	24.31	54.77

Group-I (0-1.20 ha), Group-II (1.20-2.40 ha), Group-III (2.40ha and above), M= Male, F= Female, T= Total.

Land resources

The result indicated that the farmers total available land for use comprised of his own land, land leased in or leased out. Of the total available land for use, 94.98% was own land and 7.15% leased in land which was mostly confined to smaller size group of farm but 2.13% leased out land was confined to bigger size groups of farm (Table 3). Poor resource based compelled the farmers to leased out some portion of their land even their holding was uneconomical in size. These results showed that the sample farmers mostly cultivated their own land. However, farmers of lower farm size group also cultivated very small area of land taken on lease or rent from outside. It was also indicated that the average land holding of farmers was 0.72 ha for group I, 1.67 ha for group II and 3.54 ha for group III with an average land holding of sample population was 1.77 ha which was higher than the average land holding of West Garo Hills district (0.71 ha) and in Meghalaya (0.97 ha) as a whole.

Table 2. Farm family working force and its occupational pattern for various size groups of wetland rice grower.

Size group (ha)	Total sample population	Workers			Primary occupational pattern								Secondary occupational pattern					
					Agriculture		Service		Business		others		Agriculture		Business		others	
		M	F	T	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Group-I	270	70	62	132	54	53	2	2	10	2	4	5	14	15	19	12	37	35
Per cent	100	25.93	22.96	48.89	40.91	40.15	1.52	1.52	7.58	1.52	3.03	3.79	10.61	11.36	14.39	9.09	28.03	26.52
Group-II	273	77	74	151	58	54	5	7	11	8	3	4	29	35	20	17	28	22
Per cent	100	28.21	27.11	55.31	38.41	35.76	3.31	4.64	7.28	5.30	1.99	2.65	19.21	23.18	13.25	11.26	18.54	14.57
Group -III	222	70	56	126	52	44	7	5	10	6	1	1	49	44	20	12	1	0
Per cent	100	31.53	25.23	56.76	41.27	34.92	5.56	3.97	7.94	4.76	0.79	0.79	38.89	34.92	15.87	9.52	0.79	0.00
Total	**765**	**217**	**192**	**409**	**164**	**151**	**14**	**14**	**31**	**16**	**8**	**10**	**92**	**94**	**59**	**41**	**66**	**57**
Per cent	100	28.37	25.10	53.46	40.10	36.92	3.42	3.42	7.58	3.91	1.96	2.44	22.49	22.98	14.43	10.02	16.14	13.94

M= Male, F= Female, T= Total.

Land use pattern

The land use pattern of various size groups of wetland rice farmers are presented in Table 4. It was observed that the total operational holding constituted about 89.17% of total available land for use. This was followed by land under dwelling house, permanent fallow and for cow/pig/poultry shed. But different size groups of wetland rice farmers, proportion of land under operational holding was more in lower size groups (group I) while land under dwelling house and permanent fallow were more in higher size group (group III) of farmers. Of the total operational holding, maximum proportion (74.48%) was under cultivated holding followed by plantation (9.35%) and fishery (2.71%).

Table 3. Land resource for various size groups of wetland rice farmers (in ha).

Size group (ha)	Sample size	Land owned	Leased in land	Leased out land	Total land available for use	Average land holding
Group -I	46	29.20	3.87	0.00	33.07	0.72
Per cent		88.31	11.69	0.00	100.00	
Group -II	44	67.40	6.40	0.40	73.40	1.67
Per cent		91.83	8.72	0.54	100.00	
Group -III	30	105.27	4.93	4.13	106.07	3.54
Per cent		99.25	4.65	3.90	100	
Total	**120**	**201.87**	**15.20**	**4.53**	**212.54**	**1.77**
Per cent		94.98	7.15	2.13	100.00	

Further, cultivated holding as proportion to operational holding was more in lower size group of wetland rice farmers while that of plantation crops and fishery was more in higher size groups of farmers. The average size of operational holding of wetland rice farmers as a whole was found to be 1.76 ha which showed a positive relationship with the farm size. The average size of cultivated holding was found to be 1.43 ha. Among the various size groups, the average size of cultivated holding was found to be least in group I followed by group II & III.

The result indicated that about 74.48% of cultivated land was used for cultivation of wetland rice followed by plantation crops and fishery. Even then, cultivation of wetland rice was relatively more important for lower size groups of farmers while plantation and fishery was relatively more important n higher size groups of farmers in the sample population in the study area.

Table 4. Land use pattern of various size group of wetland rice farmers (in ha).

Size group (ha)	Total land available for use	Land under dwelling house	Land under cowshed/ piggery/ poultry shed	Permanent fallow land	Total operational holding	Land under plantation crops	Land under fishery	Cultivated holding	Average size of operational holding	Average size of cultivated holding
Group -I	33.07	1.16	0.56	0.27	31.08	1.40	0.00	29.67	0.68	0.65
Per cent	100.00	3.52	1.7	0.81	93.98	4.24	0.00	89.74		
Group -II	73.40	3.03	1.41	1.07	67.90	4.79	1.50	61.61	1.54	1.40
Per cent	100.00	4.12	1.92	1.45	92.51	6.53	2.04	83.93		
Group -III	106.07	4.97	1.43	8.13	91.53	13.67	4.27	67.00	3.05	2.23
Per cent	100	4.68	1.35	7.67	86.30	12.88	4.02	63.17		
Total	**212.54**	**9.16**	**3.41**	**9.47**	**190.51**	**19.86**	**5.77**	**158.28**	**1.76**	**1.43**
Per cent	100.00	4.31	1.60	4.45	89.63	9.35	2.71	74.47		

Cropping pattern

The sample farmers used to grow mostly wetland rice, maize, jute, *rabi* vegetables, mustard, lentil, wheat, potato, tomato, pulses etc (Table 5). Wetland rice was the major crop accounting for about 71.78 % of total cropped area. It was followed by mustard (9.22%) *rabi* vegetables (5.56%), others including pulses (4.60%), jute (3.08%), maize (2.94%). Lentil, Potato, wheat and tomato accounted for minor area. The importance of wetland rice was more in group I followed by group III and II as the small size groups more depended on wetland rice.

Table 5. Cropping pattern for various size groups of wetland rice farmers (in ha).

Crops	Group –I		Group –II		Group –III		Average	
	Area	Per cent	Area	Per cent	Area	Per cent	Area	Per cent
Wetland rice	0.549	85.80	1.18	67.75	2.19	70.91	1.31	71.78
Maize	0.012	1.83	0.03	1.52	0.12	3.96	0.05	2.94
Jute	0.009	1.36	0.07	4.18	0.09	2.80	0.06	3.08
Rabi vegetables	0.016	2.46	0.11	6.18	0.18	5.83	0.10	5.56
Mustard	0.044	6.86	0.19	10.71	0.27	8.85	0.17	9.22
Lentil	0.000	0.00	0.00	0.17	0.02	0.58	0.01	0.38
wheat	0.000	0.00	0.05	2.61	0.02	0.65	0.02	1.20
Potato	0.000	0.00	0.03	1.48	0.03	1.08	0.02	1.08
Tomato	0.000	0.00	0.01	0.52	0.01	0.25	0.01	0.31
Others	0.011	1.70	0.08	4.88	0.16	5.03	0.08	4.60
Gross cropped area	0.64	100.00	1.74	100.00	3.09	100.00	1.82	100.00
Net cropped area	0.62		1.40		2.23		1.42	
Cropping intensity (%)	**103.23**		**124.29**		**138.57**		**128.36**	

The highest area under wetland rice (85.80%) was under the size group I and lowest in group II. The average cropping intensity was 128.36 % in the sample population which was found to be higher than the state average of 121.33 % and at par with the district average cropping intensity of 129.90% (Anonymous, 2008-09). However, between different farm size groups, the cropping intensity increased with the increased in farm size. The highest cropping intensity was recorded with size group III (138.57%) which indicated that about 38.57% area was covered under double crops in the study area.

Resource use efficiency

The influence of production inputs on wetland rice output was determined with the aid of production function analysis. The main objectives of any production unit are the better co-ordination and utilization of various resources to realize greater returns. In this section, an attempt was made to analyze the productivity of various resources in the production of wetland rice in various size groups. The analysis was done separately for each size groups for the study on per hectare basis in order to determine whether or not the factors of production were used optimally. To study the resource use efficiency (technical and economic efficiency), the Cobb-Douglas production function (monetary terms) was fitted to the data by taking gross returns as dependent variable and cost incurred on various production units like land, seeds, fertilizers, FYM/ vermicompost, weedicides, pesticides, human labour, bullock labour, fencing, power tiller, irrigation, machinery/implements and marketing as independent variables. The resource use efficiency analysis assumes greater importance in ascertaining whether production at the farm level and in turn of the region could be increased to an optimal level by making reallocation of existing resources. The direct estimates of production function were used to test the efficiency of different production inputs. Average physical productivity (APP), marginal physical productivity (MPP), marginal value product (MVP), profitability ratio (MVP/MFC), efficiency gap and per cent divergence was calculated at the geometric mean level of various production inputs and output level in monetary terms. The opportunity cost (MFC) of all the inputs considered for study was valued as market price per unit of all the inputs.

The Cobb-Douglas type of production function was fitted to primary data collected from the farmers for each of the three size groups of wetland rice farmers and for overall study area.

Technical and economic efficiency of resource use

The technical efficiency or production elasticity (E_p) and economic or allocative efficiency (r) of wetland rice cultivation under different size groups are presented in Table 6. The co-efficient of multiple determinations (R^2) of the production function was 0.599 in size group I, 0.684 in group II and 0.881 in group III which indicated that about 59.9, 68.4 and 88.1 % of the variation in productivity of wetland rice in size groups I, II and II, respectively which were explained by the independent variables. However, about 67.1% in overall income of the farm depends on the independent variables.

The technical efficiency or elasticity co-efficient (E_p) for land (X_1), seed (X_2), fertilizer(X_3), FYM/vermicompost (X_4), weedicides (X_5), pesticides (X_6), human labour (X_7), bullock labour (X_8), fencing(X_9), power tiller(X_{10}), Irrigation(X_{11}), machinery/implements (X_{12}) and marketing (X_{13}) were statistically non-significant in size group I and group II and significant in group III and overall farm which indicated that the productivity of wetland rice showed a decreasing return to scale as the proportionate change of output is less than proportionate change in input use for wetland rice cultivation(E_p<1). However, the negative elasticity co-efficient for seeds (X_2), weedicides(X_5) and machinery/implements (X_{12} in size group I, fertilizer(X_3), weedicides (X_5), bullock labour (X_8) and Irrigation(X_{11}) in size group II and FYM/vermicompost (X_4), weedicides (X_5), human labour (X_7), fencing(X_9), Irrigation(X_{11}) and marketing (X_{13}) in group III, but these were statistically non-significant in group I and group II and significant in group III, indicating that a marginal increase in the amount of these input would not raise the total value of output realized. Similarly, the negative coefficient of elasticity showed imbalanced use of these inputs. On the other hand, the overall technical efficiency was found statistically significant in inputs like land (X_1), seeds (X_2), fertilizer(X_3) and FYM/vermicompost (X_4). Similar result was also reported by Nandhini *et al*., (2006), Oniah *et al.,* (2008), Suresh and Reddy (2006). The sum of technical efficiency or elasticity coefficient ($\Sigma E_p<1$)of inputs was 0.4048 in size group I and 0.4659 in group II, 0.3441 in group III and overall (0.6298) showed decreasing return to scale as the proportionate change of output is less than proportionate change in input use for wetland rice cultivation.

The estimates of economic or allocative efficiency (r) of inputs used by wetland rice farmers in the study area indicated that the farmers were efficiently utilized fertilizers, FYM/vermicompost, pesticides, bullock labour and irrigation in size group I, FYM/vermicompost in size group II, seeds, fertilizers, pesticides, bullock labour in size group III and land, fertilizer, FYM/vermicompost and irrigation in overall resources in wetland rice cultivation (r>1). This suggests that wetland rice farmers in the area can increase their rice output by employing more of these resources. However, the remaining resources were inefficiently utilized i.e. over utilized in all the size groups of wetland rice farmers as the ratio of marginal value products (MVPs) to their respective marginal factor cost (MFCs) for the inputs were less than unity (r<1). It means diminishing returns to individual factors (Patil and Acharya, 1974; Suresh and Reddy, 2006). It was

Table 6. Estimates of technical efficiency (E_p) and economic efficiency (r) of resource use in wetland rice cultivation under different size groups.

Variables	Size groups							
	Group -I		Group -II		Group -III		Overall	
	Technical efficiency (E_p)	Economic efficiency (r)	Technical efficiency (E_p)	Economic efficiency (r)	Technical efficiency (E_p)	Economic efficiency (r)	Technical efficiency (E_p)	Economic efficiency (r)
Constant	1.8812		1.5757		0.7153		3.3305*	
Land (X_1)	0.3334	0.483	0.1241	0.018	0.5032	0.039	0.6550*	1.512
Seeds(X_2)	-0.0148	-0.401	0.0306	0.427	0.2430*	4.308	0.3977*	0.657
Fertilizers(X_3)	0.0003	3.504	-0.0005	-0.686	0.0021*	2.965	0.0234**	6.582
FYM/Vermicompost(X_4)	0.0018	2.520	0.0002	2.103	-0.0055*	-2.240	0.0290*	5.946
Weedicides(X_5)	-0.0006	-0.559	-0.0162	-2.944	-0.0022*	-1.823	-0.0528	-2.418
Pesticides(X_6)	0.0028	1.216	0.0003	0.019	0.0387*	3.063	-0.1237	-1.510
Human labour(X_7)	0.0387	0.030	0.2318	0.116	-0.2433	-0.130	0.2913	0.529
Bullock labour(X_8)	0.0049	2.763	-0.0022	-1.067	0.0135	3.832	0.0193	0.786
Fencing(X_9)	0.0076	0.197	0.0049	0.831	-0.0324	-2.957	-0.0609	-0.389
Tractor/Power tiller(X_{10})	0.0029	0.002	0.0679	0.020	0.0399	0.034	-0.2165	-1.105
Irrigation(X_{11})	0.1915	1.939	-0.1043	-1.328	-0.0005	-0.012	0.1062*	1.384
Machinery/implements(X_{12})	-0.0011	-0.011	0.0070	0.028	0.0328**	0.810	-0.3292	-2.831
Marketing(X_{13})	1.8812	-0.692	0.1224	0.873	-0.2453*	-1.032	-0.1090*	-5.289
Return to scales	0.4048		0.4659		0.3441		0.6298	
R^2	0.599		0.684		0.881		0.671	
No of observation	46		44		30		120	

Significant at 5 % probability level, ** Significant at 1% probability level.

also observed that the inputs like seeds, weedicides, machinery/implements and marketing in size group I; fertilizer, weedicides, bullock labour and irrigation in group II as well as FYM/vermicompost, weedicides, human labour, fencing, irrigation and marketing showed negative value of economic or allocative efficiency (r) indicating excessive/ imbalanced use of these inputs for cultivation of wetland rice in the study area. The negative allocative efficiency indicated that an additional expenditure of one rupee on these account would reduce the return and the fixed resources were no longer responsive to the variable input applied (Suresh and Reddy, 2006).

Hence, to be economically efficient, the farmers had to reduce the amount of

Table 7. Overall estimates of efficiency parameters for economic use of resources in wetland rice cultivation.

Resources	Geometric Mean	APP	MPP	MVP	MFC	Profitability ratio	Efficiency gap	Divergence (%)
Land (X_1)	13.27	184.70	120.98	1512.24	1000	1.512	512.24	33.87
Seeds(X_2)	741.80	3.30	1.31	16.42	25	0.657	-8.58	-52.21
Fertilizers(X_3)	13.59	180.35	4.21	52.65	8	6.582	44.65	84.81
FYM/Vermicompost(X_4)	14.95	163.95	4.76	59.46	10	5.946	49.46	83.18
Weedicides(X_5)	3.04	805.72	-42.56	-532.03	220	-2.418	-752.03	141.35
Pesticides(X_6)	6.67	366.15	-45.30	-566.24	375	-1.510	-941.24	166.23
Human labour(X_7)	168.80	14.52	4.23	52.88	100	0.529	-47.12	-89.11
Bullock labour(X_8)	2.51	978.44	18.87	235.88	300	0.786	-64.12	-27.18
Fencing(X_9)	3.20	766.90	-46.69	-583.59	1500	-0.389	-2083.59	357.03
Power tiller(X_{10})	24.02	102.04	-22.09	-276.17	250	-1.105	-526.17	190.52
Irrigation(X_{11})	15.68	156.31	16.61	207.59	1500	1.384	57.59	27.74
Machinery/implements(X_{12})	2.38	1032.00	-339.70	-426.29	150	-2.831	-5746.29	135.32
Marketing(X_{13})	2.10	1164.92	-126.94	-1586.70	300	-5.289	-1886.70	118.91

these inputs use to increase the wetland rice productivity. This result supports the findings of Goni *et al.,* (2007), Balappa and Hugar (2005), Sharma *et al.,*(2008), Banik (1994), Nagaraj (1995) and Koppad (1993). Overall values of economic efficiency indicated that the farmers were efficiently utilized the available resources like land, fertilizer/vermicompost and irrigation for wetland rice cultivation which use could be increased to have more production of wetland rice(r>1). All other resources were utilized inefficiently or over utilized/imbalanced use and one unit increase of these resources may reduce the productivity of wetland rice.

Technical efficiency parameters of resource use

The measurement technical efficiency parameters of resources use such as Average Physical Product (APP), Marginal Physical Product (MPP), Marginal Value Product (MVP), Marginal Factor Cost MFC), profitability ratio (MVP/MFC), efficiency gap and per cent divergence were derived from overall samples in wetland rice cultivation. Overall estimates of efficiency parameters for economic use of resources in wetland rice cultivation are presented in Table 7. The values of the MPP showed that the farmers were technically more efficient in the use of land than all the resources for higher productivity of wetland rice in the study area. This suggests that if additional hectares were available, it would lead to an increase in rice productivity by 120.98 kg among the farmers. This implies that the farmers are more technically efficient in the use of land for wetland rice cultivation.

Of all the resources used, weedicides(X_5), pesticides(X_6), fencing (X_9), power tiller(X_9), machinery/implements (X_{12}) and marketing(X_{13}) had the negative MPP values which indicated the inefficiency or imbalanced or over utilized of these resources. Given the level of technology and prices of both inputs and outputs, efficiency of resource use was further ascertained by equating the MVP to the productive MFC of resources. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC i.e. if the ratio of MVP to MFC or profitability ratio equal to unity (1). Table 7 further revealed that the profitability ratio were more than unity (1) for land, fertilizer, FYM/vermicompost and irrigation but less than unity values were recorded in all other resource. This implies that land, fertilizer, FYM/vermicompost and irrigation were under-utilized (>1) while all other inputs were over- utilized (<1). This means that rice output was likely to increase and hence revenue of such inputs (land, fertilizer, FYM/vermicompost and irrigation) had been utilized.

The adjustment in the MVPs for optimal resource use (% divergence) in Table 7 indicated that for optimal allocation of resources about 33.87, 84.81, 83.18, 141.35, 166.23, 357.03, 190.52, 27.74, 135.32, 118.91 % increase in land, fertilizers, FYM/vermicompost, weedicides, pesticides, fencing, power tiller, irrigation, machinery/implements and marketing, respectively while seeds, human labour and bullock labour were over utilized which required 52.21, 89.11, 27.18 % reduction for optimal use in wetland rice production. This result was in conformity with the findings of Goni *et al*., (2007).

CONCLUSION

Findings from this study revealed that wetland rice farmers were technically inefficient in the use of farm resources. The inefficiency of the farmers may be directly or indirectly linked to the traditional cultivation practices, high cost of fertilizer, rent and improved seeds. The implication of the study was that technical efficiency in wetland rice production in West Garo Hills district of Meghalaya could be increased through better use of land, fertilizer and improved seeds. The improvement of the efficiency among farmers is the responsibility of the individual farmers, government and research institutions. There should be improvement in extension services delivery. The provision of improved rural infrastructures and enabling policies such as making available all agricultural inputs required at the right time and affordable prices among others are also required in order to enhance efficiency. In addition, there should be policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in wetland rice production in the district. Hence, the hill farmers should be educated on reallocation of resources with better management and awareness generation, adoption of new inputs and technologies for improving production of wetland rice.

REFERENCES

Ali M, Chowdhury MA (1991). Inter-farm efficiency of Pakistan's Punjab: A frontier production function study. J Agric Eco 41(1): 62-74.

Anonymous, (2008-09). Government of Meghalaya, *Statistical Hand Book, Meghalaya,* Directorate of Economics and Statistics, Shillong. pp. 40.

Balappa S, Hugar LB (2005). Measurement of production efficiency in potato-An evidence of Karnataka state. Asian Eco Rev 47(1):124-131.

Bali SA, Singh M, Kachroo D, Sharma BC and Shivran DR (2006). Efficacy of herbicides in transplanted medium duration rice (*Oryza sativa*) under subtropical conditions of Jammu. Indian J Agron 51(2):128-130.

Banik A (1994). Technical efficiency of irrigated farms in a village of Bangladesh. Indian J Agric Eco 49(1):70-78.

Farrel MJ (1957). The measurement of production efficiency. J Stat Soc Sci 120(3):253-290.

Goni M, Mohammed S, Baba BA (2007). Analysis of Resource Use Efficiency in Rice production in the Lake Chad Area of Borno State, Nigeria. J. Sust. Dev. Agric. Env. 3: 31-37

Kalita, DC (1996). Financing of fishery by commercial banks under IRDP. M.Sc. (Agri.) Thesis submitted to Assam Agricultural University, Jorhat.

Nagaraj T (1995). An economic analysis of cropping systems in Tungabhadra Project Command Area. M.Sc. (Agri.) Thesis submitted *to* University of Agricultural Sciences, Dharwad.

Nagaraj T, Khan HSS, Shankaramurthy HG, Vijaykumar HS (1998). Resource-use pattern and yield obtained in different cropping systems in Tungabhadra Project Command Area. Agric Situ India 52(3): 121-125.

Nandhini US, Alagumani T, Shibi S (2006). Economic analysis of agriculture in Southern parts of coastal India. Agric Tropica ET Subtropica 39(4):279-284.

Oniah MO, Kuye OO, Idiong IC (2008). Efficiency of Resource Use in Small Scale Swamp Rice Production in Obubra Local Government Area of Cross River State, Nigeria. Middle-East J Sci Res 3 (3): 145-148.

Patil NP, Acharya TKT (1974). A comparative study of resource productivity and resource allocation on sample sugarcane and banana farms in Nasik, Jalagoan district of Maharashtra". Indian J Agric Eco 29(3): 186-187.

Suresh A, Reddy TRK (2006). Resource Use Efficiency of paddy cultivation in Peech Command Area of Thrissur district of Kerala: An Economic Analysis. Agric Eco Res Rev 19**:** 159-171.