Assessment of Techno-economic and Allocative efficiencies of maize in Western Maharashtra through data envelopment analysis

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Abstract

Background: Maize (*Zea mays* L.) is considered as queen of cereals and an important cereal crops, next only to rice and wheat.
Methodology: The present investigation was conformed to the database of the cpmcc scheme.
Findings: The increase in the use of hired human labour was observed with increase in the size group of holdings, while decrease in use of resources like family labour, machine labour, seed and nitrogenous fertilizers was noticed with increase in size group of holdings. Per hectare cost of cultivation of maize was `26150.39 while gross returns were `31335.95. The net profit at Cost 'C' was ` 5185.57 and B:C ratio was 1.20. In case of resource use gap excess use was observed in case of seed and nitrogen fertilizers while less use of manures, phosphorous and potash was observed. Technical efficiencies on small, medium and large maize farms were 0.992, 0.953 and 0.970, respectively and 27 small, 23 medium and 25 large farms were technically efficient. Allocative and economic efficiencies of maize farms revealed that not a single small farm, only one medium farm and not a single large farm were economically and allocatively efficient. While, 7 small farms, 6 medium farms and 7 large farms have economic efficiency more than 50 per cent. Cost minimizing input quantities revealed that small, medium and large maize farms could reduce its cost by 66.90, 61.40 and 42.02 per cent, respectively by choosing a more cost efficient input mix for allocatively efficient farms. The cost minimization on small maize farms was `3880.42 while on medium farms it was `3281.50 and on large farms `4045.69 by using a new cost efficient input mix.
Application/Improvements: Optimum utilization of all other resources by the farmers will have to be ensured for higher production by passing on the crop production technologies to them by using the effective extension measures

***Keywords*:** Maize, Input utilization, Resource use gap, Costs and returns structure, Technical efficiency, Allocative and economic efficiencies

1. Introduction

Maize (*Zea mays* L.) considered as queen of the cereal is one of the most important cereal crops in the world, next only to rice and wheat. Worldwide area, production and productivity of maize are 137 million ha, 610 million tones and 4.45 t/ha, respectively. In India during 2006-07 maize was grown in an area of 7.42 million ha with the production and productivity of 14.72 million tones and 1,983 kg/ha, respectively. Major proportion (55 %) of maize is consumed as food and additional use of maize includes as feed, forage and in processing industry. Maize is one of the most important cereals of the world. The demand for maize has risen rather steeply during the past five years. Rising incomes in India and the consequent growth in meat and poultry consumption have resulted in rapid increase in the demand for maize as feed. Out of the total arrivals in the mandis, nearly 75 per cent of the produce is bought by the poultry feed manufacturers and 20 per cent by the starch extractors, and the rest by alcoholic and beverages manufacturing industry. India stands at 5th position with 3 per cent of production and it contributing about 2 per cent of global trade. Andhra Pradesh is the leading maize producing state in India contributing about 21 per cent of total production, followed by Karnataka (16 %), Rajasthan (10 %), Bihar and Maharashtra (9 % each) and Uttar Pradesh and Madhya Pradesh (6 % each).The major trading centres of maize in Maharashtra are Sangli, Dhule, Jalna, Satara, Nandurbar, Pandharpur, Chalisgaon, Malegaon, Chikhali, Latur, Akluj, Dondaicha, Aurangabad and Nashik. The harvesting period of *kharif* maize is from 1st October to 15th October and markets start receiving arrivals in 2nd fortnight of October. The present investigation viz., "Assessment of Techno-economic and Allocative Efficiencies of Maize in Western Maharashtra through Data Envelopment Analysis" is an attempt to study the resource use

structure, resource use gap and costs and returns structure , to estimate the economic, technical, and allocative efficiencies ,to estimate the extent of reduction in level of inputs at existing levels of output and to estimate the extent of reduction in input cost of production at existing levels of output.

2. Methodology

The present investigation was conformed to the database of the CPMCC scheme Sponsored by state Government of Maharashtra. The sample farms in different villages spread over 10 districts of Western Maharashtra were considered for the present study [1].

As such, the sampling design adopted in the scheme consisted of three stage stratified random sampling with homogeneous crop growing zones as strata, tahsil as a primary unit, a cluster of villages as secondary unit and land holding within the cluster as an ultimate unit of sampling. The study covers quite a substantial number of holdings selected by adopting a scientific sampling technique, keeping in view of maintaining the adequate sample size. The crop complex as well as individual crop approach was adopted in collection of data under the scheme [2].

3. Result and Discussion

3.1. Input utilization on maize farms

Input utilized for production of maize and its prices on three different size groups of holdings for the years 2009-10 to 2011-12 were worked out and the triennium average is presented in Table 1.

Table 1. Input utilization on maize farms

(Per ha)

Sr. No.	Particulars	Size group			
		Small	Medium	Large	Overall
A	**Inputs**				
1	Area (ha)	14.02	20.38	27.19	61.59
2	Total Hired Labour (man-days)	49.96	54.07	66.91	58.81
	a) Male	20.13	18.54	22.94	20.85
	b) Female	29.83	35.53	43.98	37.96
3	Total Family Labour (man-days)	32.00	27.86	20.15	25.40
	a) Male	15.95	16.37	12.22	14.44
	b) Female	16.05	11.49	7.92	10.95
4	Bullock Power (pair-day)	5.77	7.15	6.41	6.51
5	Machine Power (hr)	13.12	10.13	9.93	10.72
6	Seed (kg/ha)	19.88	17.41	16.83	17.72
7	Organic manure (q)	12.11	14.51	11.83	12.78
8	Nitrogen (kg)	93.63	70.18	69.67	75.29
9	Phosphorus (kg)	51.56	33.58	43.84	42.20
10	Potassium (kg)	26.61	23.55	25.48	25.10
11	**Output- yield (q/ha)**	27.17	27.56	27.37	27.39
B	**Price of Inputs**				
1	Wage (`/day)				
	a) Male	117.35	115.70	115.66	116.20
	b) Female	86.87	85.34	83.01	84.66
2	Bullock Power (`/pair-day)	373.26	403.96	304.12	354.35
3	Mechanical Power (`/hr)	32.34	29.71	37.40	33.59
4	Seed price (`/kg)	154.25	147.26	142.63	147.10
5	Organic manure (`/q)	73.92	94.01	113.26	97.54
6	Nitrogen (`/kg)	13.35	14.12	15.22	14.35
7	Phosphorus (`/kg)	17.18	19.45	21.47	19.75
8	Potassium (`/kg)	8.17	8.48	9.93	9.06
	Price of output (`/q)	943.21	934.56	951.39	943.93

Resource use structure of maize revealed that, the seed utilized at the overall level was 17.72 kg/ha for the study period. The human labour utilized per hectare was 84.21 man-days. The bullock labour use was 6.51 pair days/ha and utilization of machine power was 10.72 hrs/ha. The maize farms have applied 12.78 quintals of organic manure per hectare. The average nitrogen utilized by the farms was 75.29 kg/ha, whereas phosphorus used was 42.20 kg/ha and 25.10 kg/ha of potassic fertilizer. The average output of maize was 27.39 q/ha. The study on maize pointed out that, increase in the use of hired human labour was observed with increase in the size group of holdings, indicating economies of scale, while decrease in use of resources like family labour, machine labour, seed and nitrogenous fertilizers was noticed with increase in size group of holdings. Higher level of input utilization was observed in case of bullock labour and organic manure on medium size group of holdings. However, lower level of input utilization was observed in case of phosphorus and potash fertilizers on medium size group of holding [3].

At the overall level the prices of inputs like seed, manures, N, P and K fertilizers were `147.10/kg, `97.54/quintal, `14.35/kg, `19.75/kg and `9.06/kg, respectively during the study period. The wages of male and female labour were `116.20/day and `84.66/day, respectively. The bullock labour charges were `354.35 and charges of machine power were `33.59/hr during the study period. Per quintal price of maize was `943.93 [4].

3.2. Resource use gap on maize farms

The production of maize depends on judicious and balanced use of inputs. In the light of these specific relationships between inputs and output of maize, the data have been analyzed further to work out the gaps in the actual use of levels and recommended levels of inputs and resultant output of maize. The results obtained from the analysis are presented in Table 2.

Table 2. Resource use gap on maize farms

(Per ha)

Sr. No.	Particulars	Size group			
		Small	Medium	Large	Overall
I	**Seed (kg)**				
A	Recommended	17.00	17.00	17.00	17.00
B	Actual use	19.88	17.41	16.83	17.72
C	Gap	-2.88	-0.41	0.17	-0.72
D	Per cent gap	-16.96	-2.43	1.01	-4.22
II	**Manure (qtls)**				
A	Recommended	60.00	60.00	60.00	60.00
B	Actual use	12.11	14.51	11.83	12.78
C	Gap	47.89	45.49	48.17	47.22
D	Per cent gap	79.82	75.82	80.29	78.70
III	**Nitrogen (kg)**				
A	Recommended	80.00	80.00	80.00	80.00
B	Actual use	93.63	70.18	69.67	75.29
C	Gap	-13.63	9.82	10.33	4.71
D	Per cent gap	-17.03	12.28	12.91	5.88
IV	**Phosphorus (kg)**				
A	Recommended	60.00	60.00	60.00	60.00
B	Actual use	51.56	33.58	43.84	42.20
C	Gap	8.44	26.42	16.16	17.80
D	Per cent gap	14.06	44.04	26.93	29.66
V	**Potash (kg)**				
A	Recommended	40.00	40.00	40.00	40.00
B	Actual use	26.61	23.55	25.48	25.10
C	Gap	13.39	16.45	14.52	14.90
D	Per cent gap	33.47	41.12	36.31	37.25
VI	**Yield (qtls)**				
A	Recommended	30.00	30.00	30.00	30.00
B	Actual use	27.17	27.56	27.37	27.39
C	Gap	2.83	2.44	2.63	2.61
D	Per cent gap	9.45	8.15	8.75	8.71

According to Table 2, it has been clearly indicated that except the large farms (1.01%) excess use in the seed quantity was observed than the recommended levels of inputs. While in case of nitrogen fertilizer the excess use (17.03%) was observed on small farms except all other inputs and the less use of inputs was observed on all size groups of holdings. Notable gap was observed in use of manures, which was 78.80 per cent. In case of use of

phosphorous, at the overall level the gap was 29.66 per cent, and in potash the gap was 37.25 per cent. In case of yield, there were no too much variations and as a result the yield gap was 8.71 per cent [5].

3.3. Costs and returns structure on maize farms

Maize crop is considered as a heavy feeder among the other *kharif* food grain crops. The cost of cultivation of maize was worked out and the detailed costs and returns structure on different categories of maize farms and at the overall level for the years 2009-10 to 2011-12 were examined and the triennium average is presented in Table 3.

Table 3. Costs and returns structure on maize farms

(Per ha)

Sr. No.	Particulars	Size group			
		Small	Medium	Large	Overall
1	Total cost				
	i) Cost 'A'	17317.66	17327.21	17280.31	17304.33
	ii) Cost 'B'	23617.98	23425.40	23404.79	23460.14
	iii) Cost 'C'	26979.57	26404.83	25532.12	26150.39
2	Profit at				
	i) Cost 'A'	13285.67	14205.50	14285.93	14031.62
	ii) Cost 'B'	6985.35	8107.32	8161.44	7875.81
	iii) Cost 'C'	3623.76	5127.88	6034.11	5185.57
4	Gross income	30603.33	31532.72	31566.24	31335.95
5	B:C ratio				
	i) Cost 'A'	1.77	1.82	1.83	1.81
	ii) Cost 'B'	1.30	1.35	1.35	1.34
	iii) Cost 'C'	1.13	1.19	1.24	1.20

Costs and returns structure revealed that per hectare cost of cultivation of maize was `26979.57, `26404.83 and `25532.12 on small, medium and large size group of holdings, respectively and it has decreased with the increase in the size group of holdings and at the overall level it was `26150.39. Costs and returns structure revealed that per hectare cost of cultivation of maize was `26979.57, `26404.83 and `25532.12 on small, medium and large size group of holdings, respectively and it has decreased with the increase in the size group of holdings and at the overall level it was `26150.39. Gross income was `30603.33, `31532.72 and `31566.24 on small, medium and large size group of holdings, respectively and it has increased with the increase in the size group of holdings and at the overall level it was `31335.95. The net profit at Cost 'C' was `3623.76, `5127.88 and `6034.11 on small, medium and large size group of holdings, respectively and it has also increased with the increase in the size group of holdings and at the overall level it was `5185.57. The benefit: cost ratio was in the range of 1.13 to 1.24 during the study period and it has increased with the increase in the size group of holdings [6,7].

3.4. Technical efficiency on *maize* farms under constant returns to scale.

Technical efficiency is the ability of a firm to produce a maximum output from a given set of inputs or it is the ability of a firm to use as modest inputs as possible for a given level of output. The technical efficiency of maize have been worked out and presented in Table 4.

Table 4. Technical efficiency of maize under constant returns to scale assumption

Sr. No.	Crop	Size group		
		Small farm	Medium farm	Large farm
1	Maize	0.992	0.953	0.970

Technical efficiency analysis of different categories on maize farms revealed that the average technical efficiency on small, medium and large farms was 0.992, 0.953 and 0.970, respectively. In case of small farms technical efficiency

was 0.992 means these farms should be able to reduce the consumption of all inputs by 0.8 per cent without reducing the output. In case of medium farms technical efficiency was 0.953 means these farms should be able to reduce the consumption of all inputs by 4.70 per cent without reducing the output. As regard the large farms, the technical efficiency was 0.970 indicating that, these farms should be able to reduce the consumption of all inputs by 3.00 per cent without reducing the output. About 27 small farms, 23 medium farms and 25 large farms were technically efficient. The technical efficiencies of small categories on maize farms were found relative more than large and medium categories of farms [8,9].

3.5. Technical efficiency score on *maize* farms under constant returns to scale assumption

Maize farms of different size group of holding were distributed as per the technical efficiency score under CRS assumption for the years 2009-10, 2010-11 and 2011-12 and pooled results are presented in Table 5.

Table 5. Technical efficiency score on maize farms under constant returns to scale assumption

Efficiency score	Size group		
	Small farms	Medium farms	Large farms
0.000 - 0.300	0	0	0
0.301 - 0.500	0	0	0
0.501 - 0.700	0	1	1
0.701 - 0.900	1	2	2
0.901 - 1.000	29	27	27
Total	**30**	**30**	**30**

Technical efficiency score on maize farms under constant returns to scale assumption showed that one medium farm and one large farm has score between 0.501-0.700 while one small, two medium and two large farms falls in the score 0.701-0.900 and 29 small, 27 medium farms and 27 large farms were technically efficient. Among the selected maize farms in western Maharashtra, 90 per cent farms were have technical efficiency score between 0.901 to 1.000 and remaining farms falls in T.E. score between 0.701 to 0.900. The proportion of technical efficient maize farms was relatively more on small farms.

3.6. Input slacks under constant returns to scale assumption

In the cultivation of maize, excess use of inputs i.e. input slacks were calculated under constant returns to scale assumption during 2009-10 to 2011-12 and triennium average data are presented in Table 6.

Table 6. Input slacks on maize farms under constant returns to scale assumption

Sr. No.	Inputs	Size group		
		Small	Medium	Large
1	Technical efficiency	0.992	0.953	0.970
2	Hired labour			
	a) Male	3.93	5.21	2.07
	b) Female	5.01	9.81	8.51
3	Bullock labour	0.26	3.20	2.27
4	Machine labour	0.13	0.42	0.45
5	Seed	0.12	0.32	0.12
6	Organic manure	0.22	0.35	0.57
7	Fertilizers			
	a) N	5.22	8.39	2.53
	b) P	1.10	5.28	2.04
	c) K	1.61	2.87	1.74
8	Family human labour			
	a) Male	2.93	2.42	4.15
	b) Female	1.69	4.32	2.86

The summary of input slacks on small farms under constant returns to scale assumption showed that 29 small farms have the technical efficiency as 1, which indicates that on these farms no further reduction in inputs can be

done or the farms have any excess inputs. The input slacks were highest in nitrogenous fertilizer, family female labour, hired male labour bullock labour and family male labour. This means that small farms have excess use of inputs like nitrogenous fertilizer (5.22 kg), hired female labour (5.01 man-days), hired male labour (3.93 man days), family male labour (2.93 man days) and family female labour (1.69 man days). The lowest input slacks were observed in seed (0.12 man-days), machine labour (0.13 hrs) and organic manure (0.22 qtls).The summary of input slacks on medium farms under CRS revealed that 27 farms are technically efficient. The input slacks were highest in case of hired female labour (9.81 man-days), 'N' fertilizers (8.39 kg), 'P' fertilizers (5.28 kg), hired male labour (5.21 man-days), family female labour (4.32 man-days), bullock labour (3.20 pair days) which indicates the excess use of these resources. The lowest input slacks were recorded in case of seed (0.32 man-days), organic manure (0.35 qtls) and machine labour (0.13 hrs). The input slacks on large farms under CRS assumption indicated that about 27 farms were technically efficient and the input slacks were highest in case of hired female labour (8.51 man-days), family male labour (4.15 man-days), family female labour (2.86 man-days), 'N' fertilizers (2.53 kg), bullock labour (2.27 pair-days), hired male labour (2.07 man-days), 'P' fertilizers (2.04 kg) and 'K' fertilizers (1.74 kg), The lowest input slacks were observed in case of seed (0.12 kg), machine power (0.45 hrs) and organic manure (0.57 qtls).

The technical efficiencies of all categories of maize farms during three years of study period were in the range of 0.953 to 0.992 and these figures of technical efficiencies indicated that there were no possibilities of less use of resources and this picture depicted in the result. The inputs like hired male labour, hired female labour and family female labour was used excessively. The inputs like seed, machine labour and organic manure were used optimally as there was no excess use of these three inputs on selected farms.

3.7. Technical efficiency under CRS, technical efficiency under VRS and scale efficiency

The technical efficiencies under VRS and CRS and scale efficiency of maize farms for different size group of holdings during 2009-10 to 2011-12 and the triennium average data are shown in Table. 7

Table 7. Technical efficiency under CRS, VRS and Scale efficiency on maize farms

Crop/Group	Technical efficiency		
	Constant Returns to Scale (CRS)	Variable Returns to Scale (VRS)	Scale
Small	0.992	0.997	0.995
Medium	0.953	0.982	0.969
Large	0.970	0.987	0.982

The technical efficiencies under VRS and CRS and scale efficiency on small farms of maize showed that when CRS was assumed all 30 farms were technically efficient whereas VRS was also assumed 30 farms were technically efficient. Under VRSTE these farms should be able to reduce the consumption of all inputs by 0.30 per cent without reducing the output. The average CRSTE, VRSTE and scale efficiency was 0.992, 0.997 and 0.995, respectively. The average CRSTE, VRSTE and scale efficiency was 1 means all the 30 farms were technically and scale efficient.The VRSTE, CRSTE and scale efficiency on medium farms revealed that only 28 farms were technically efficient whereas when VRS was assumed 28 farms were technically efficient. Under VRSTE these farms should be able to reduce the consumption of all inputs by 1.80 per cent without reducing the output. The average CRSTE, VRSTE and scale efficiency was 0.953, 0.982 and 0.969, respectively. The average CRSTE, VRSTE and scale efficiency was 1 means all the 30 farms were technically and scale efficient. As regards the large farms, CRS was assumed only 22 farms were technically efficient, when VRS was assumed 27 farms were scale efficient. Under VRSTE these farms should be able to reduce the consumption of all inputs by 1.30 per cent without reducing the output. The average CRSTE, VRSTE and scale efficiency were 0.970, 0.987 and 0.982, respectively.

DEA analysis showed that all the maize farms in all the assumptions i.e. CRSTE and VRSTE and scale were found to be efficient, while technical efficiency under constant returns to scale ranges between 0.953 to 0.992 and technical efficiency under variable returns to scale considered that farms were more technically efficient than VRSTE in the range of 0.982 to 0.997. Small farms under variable returns to scale found to be highly technically efficient.

3.8. Technical and scale efficiency score under variable returns to scale on *Maize* farms.

Detail frequencies of the technical efficiency and scale efficiency score on maize farms for different size group of holdings during the year 2009-10 to 2011-12 under VRS assumption are given and the triennium average data was presented in Table 8.

Table 8. Technical and scale efficiency score on maize farms under variable returns to scale

Efficiency score	Size group					
	Small farms		Medium farms		Large farms	
	Technically efficient farms	Scale efficient farms	Technically efficient farms	Scale efficient farms	Technically efficient farms	Scale efficient farms
0.000-0.300	0	0	0	0	0	0
0.301-0.500	0	0	0	0	0	0
0.501-0.700	0	0	0	0	0	1
0.701-0.900	0	0	2	2	1	2
0.901-1.000	30	30	28	28	29	27
Total	**30**	**30**	**30**	**30**	**30**	**30**

Technical and scale efficiency scores under VRS on small farms indicated that, All the farms were highly technical and scale efficient and efficiency lies between 0.901-1.000.The TE and SE under VRS on medium farms revealed 28 farms were technical as well as scale efficient having TE and SE lies between 0.901-1.00 while 2 farms each TE and SE lies between 0.701-0.900.The TE and SE under VRS on large farms revealed that 29 farms were technical efficient having TE lies between 0.901-1.00 and 1 farm TE between 0.701-0.900. In case of scale efficiency 27 farms having SE lies between 0.901-1.000, 2 farms having SE lies between 0.701-0.900 and 1 farm having SE lies between 0.501-0.700. Efficiency score of groundnut farms give a picture that all the small farms were highly technically efficient farms, 28 medium farms out of 30 farms and 29 large farms have technically efficient and 27 large farms have scale efficient and are in the score range between 0.701 to 1.000 which means about over 90 per cent farms were highly technical as well as scale efficient [10].

3.9. Allocative and economic efficiencies on *Maize* farms

Allocative efficiency is the ability of a firm to use inputs in optimal proportion, given their respective prices and the production technology. The allocative efficiency is calculated by the ratio of economic efficiency to the technical efficiency. The allocative and economic efficiencies were analyzed for maize for different size groups of holdings during 2009-10 to 2011-12 and the triennium average data is represented in Table 9.

Table 9. Allocative and economic efficiencies on maize farms

Year/Crop	Size group								
	Small Farm			Medium Farm			Large Farm		
	TE	AE	CE	TE	AE	CE	TE	AE	CE
	0.992	0.331	0.328	0.953	0.386	0.367	0.970	0.350	0.338

Note: TE = Technical efficiency, CE = Cost efficiency (Economic efficiency), AE = Allocative efficiency = CE/TE

Efficiencies for all the three size groups of holdings have been calculated and allocative and economic efficiency on small farms showed that out of 30 farms, not a single farm was economically and allocatively efficient. It was noted that average technical, allocative and economic efficiencies were found to be 0.992, 0.331 and 0.328, respectively. Whereas, economic efficiency of 7 small farms were more than 50 per cent. Allocative and economic efficiencies on medium farms revealed that only one farm was economically and allocatively efficient. The average economic efficiency was 63.30 per cent with 6 farms having economic efficiencies more than 50 per cent. Not a single large farm was found economically and allocatively efficient. Average technical, allocative and economic efficiencies

were 0.970, 0.350 and 0.338, respectively. Seven large farms were found economically and six farms were found allocative efficient. Average economic efficiency was 66.20 per cent. While economic efficiency of 6 large farms was more than 50 per cent [11].

3.10. Allocative and economic efficiency score on Maize farms.

From Table 10 efficiency scores of allocative and economic efficiency for different categories i.e. 0.501 to 0.700, 0.701 to 0.900 and 0.901 to 1.000 by using DEA analysis of maize have been estimated for triennium average of consequent three years i.e. 2009-10, 2010-11 and 2011-12 on small, medium and large farms.

Table 10. Allocative and economic efficiency score on maize farms

Efficiency score	Size group					
	Small farms		Medium farms		Large farms	
	AE	EE	AE	EE	AE	EE
0.000-0.300	17	17	10	12	13	14
0.301-0.500	6	6	13	12	10	10
0.501-0.700	5	5	5	4	6	5
0.701-0.900	2	2	1	1	1	1
0.901-1.000	0	0	1	1	0	0
Total	**30**	**30**	**30**	**30**	**30**	**30**

Note: AE= Allocatively efficient, EE= Economically efficient

3.11. Cost minimizing input quantities on maize farms

Maize is heavy feeder crop and it requires more quantity of inputs as compared to other cereals. Cost minimizing input quantities on maize farms during 2009-10 to 2011-12 and their triennium average was depicted in Table 11.

Table 11. Cost minimizing input quantities on maize farms

(Per ha)

Sr. No.	Input	Size group		
		Small	Medium	Large
1	Allocative efficiency	0.331	0.386	0.35
2	Area (ha)	0.39	0.54	0.74
3	Total hired labour (man-days)	10.49	14.16	13.73
	a) Male	4.16	4.60	4.02
	b) Female	6.33	9.56	9.71
4	Bullock labour (pair days)	2.24	3.86	3.89
5	Machine labour (hrs)	4.25	6.90	6.84
6	Seed (kg)	5.97	10.93	13.92
7	Organic manure (qtls)	2.48	1.91	0.80
8	Fertilizers			
	a) N (kg)	17.7	20.84	18.69
	b) P (kg)	3.05	5.90	3.95
	c) K (kg)	3.89	4.40	4.73
9	Total family labour(man-days)	13.86	23.84	28.29
	a) Male	6.76	12.35	15.25
	b) Female	7.10	11.49	13.04
10	Total human labour	24.35	38.00	42.02

The small farms average allocative efficiency was 0.331 i.e. 33.10 per cent, it implies that farms could reduce its cost by 66.90 per cent by choosing a more cost efficient input mix i.e. 0.39 ha area, 5.97 kg seed, 17.70 kg nitrogen, 3.05 kg phosphorus, 3.89 kg potash, 10.49 man days total hired labour, 2.24 pair days bullock labour and 4.25 hrs machine labour etc. Moreover, 24.35 man days total human labour could be reduced by choosing a more cost efficient input mix. This summary gives us the information on farmer could reduce its cost by how much per cent by choosing a more cost efficient input mix. As regards on medium farms, cost minimizing input quantities expressed that on these farms allocative efficiency was 0.386 means 61.40 per cent cost should be reduced with maximum in total human labour i.e.38.00 man days followed by 20.84 kg 'N' fertilizers by choosing a more cost efficient input mix for allocatively inefficient farms.On large farms, during three years of study period it was revealed that on these farms allocative efficiency was 0.350 and it means 65.00 per cent cost should be reduced with 42.02 man days in total human labours, 18.69 kg 'N' fertilizers and 13.92 kg seed by choosing a more cost efficient input mix for allocatively inefficient farms.

Maize crop requires more fertilizers as compared to other food grain crops and the cost minimizing input quantities clearly depicted that maximum use of inorganic fertilizers was observed and also reduction in input quantities was possible in these inorganic fertilizers, it was followed by family human labours. On the contrary minimum reduction was possible in bullock labour and manures in the cultivation of maize during the three years of study period.

3.12. Extent of reduction in input cost of production at existing levels of output on *Maize* farms.

On maize farms, actual reduction in cost was worked out and the estimated figures of reduction in cost by using optimal input quantities for obtaining a given level of output farms for the year 2009-10 to 2011-12 and triennium average are pointed out in Table 12.

Table 12. Estimated possible reduction in cost by using optimal input quantities on maize farms.

(`/ha)

Sr. No.	Input	Size group		
		Small	Medium	Large
1	Allocative efficiency	0.331	0.386	0.350
2	Area	359.93	297.19	708.77
3	Total hired labour	2348.65	2458.20	1615.18
	a) Male	1296.08	1307.7	937.53
	b) Female	1051.57	1150.5	677.65
4	Bullock labour	335.32	-348.54	580.26
5	Machine labour	121.70	-26.70	127.28
6	Seed	283.38	-206.8	202.75
7	Organic manure	-29.40	525.84	673.94
8	Fertilizers			
	a) N	195.95	33.45	528.46
	b) P	-36.46	218.65	584.09
	c) K	59.85	203.93	133.06
9	Total family labour	242.33	126.26	-1108.12
	a) Male	178.10	399.80	-499.67
	b) Female	64.23	-273.54	-608.45
10	Total human labour	2590.98	2584.46	507.06
11	**Total Cost reduction**	**3880.42**	**3281.5**	**4045.69**
	Percentage cost reduction	15.16	13.06	16.30

The reduction in cost of production of maize is possible on farms which are allocatively inefficient. The mean extent of reduction in input cost of production on small maize farms has been found to be `359.93 for area, `2347.65 for hired labour, `242.33 for family labour, `335.32 for bullock labour, `121.70 for machine labour, `283.38 for seed

and `195.95 for N while total reduction of cost was `3880.42 (15.16%) by using a new cost efficient input mix. The cost minimization for medium farms of maize has been found to be `3281.50 (13.06%) by using a new cost efficient input mix. Cost minimization on medium farms has been found to be to `297.19 for area, `2584.46 for total human labour, `218.65 for P and `525.84 for organic manure. The mean extent of reduction in input cost of production on large farms has been found to be `708.77 for area, `580.26 for bullock labour, `1615.18 for hired labour, `528.46 for N, `584.09 for P, `673.94 for organic manure, `127.28 for machine labour. Total reduction of cost was `4045.69 (16.30%) by using a new cost efficient input mix.

3.13. Summary and conclusions

i. The increase in the use of hired human labour was observed with increase in the size group of holdings, while decrease in use of resources like family labour, machine labour, seed and nitrogenous fertilizers was noticed with increase in size group of holdings. Per hectare cost of cultivation of maize was `26150.39 while gross returns were `31335.95. The net profit at Cost 'C' was ` 5185.57 and B:C ratio was 1.20. In case of resource use gap excess use was observed in case of seed and nitrogen fertlizers while less use of manures, phosphorous and potash was observed.

ii. Technical efficiencies on small, medium and large maize farms were 0.992, 0.953 and 0.970, respectively and 27 small 23 medium and 25 large farms were technically efficient. Allocative and economic efficiencies of maize farms revealed that not a single small farm, only one medium farm and not a single large farm were economically and allocatively efficient. While, 7 small farms, 6 medium farms and 7 large farms have economic efficiency more than 50 per cent.

Cost minimizing input quantities revealed that small, medium and large maize farms could reduce its cost by 66.90, 61.40 and 42.02 per cent, respectively by choosing a more cost efficient input mix for allocatively efficient farms. The cost minimization on small maize farms was `3880.42 while on medium farms it was `3281.50 and on large farms `4045.69 by using a new cost efficient input mix.

4. References

1. S.N. Baravkar. Assessment of techno-economic and allocative efficiencies of cotton, onion and sugarcane growers of western Maharashtra through Data Envelopment Analysis. MPKV : Rahuri, 2014.
2. G.A. Kshirsagar. Economics of production and marketing of maize in Solapur district. Unpublished M.Sc.(Agri) thesis submitted to MPKV: Rahuri, 2010.
3. S.B. Bhosale. Economics of production and marketing of red gram in Osmanabad district, Unpublished M.Sc. (Agri.) Thesis submitted to MPKV: Rahuri, 2001.
4. A.A. Jawale. Economics of production and marketing of soybean in Western Maharashtra. Unpublished M.Sc.(Agri) thesis submitted to MPKV: Rahuri, 2013.
5. D. S. Deshmukh. Economics of production and marketing of pearl miller in Beed district. Unpublished M.Sc.(Agri) thesis submitted to MAU: Parbhani, 2009.
6. V.R. Farkade. Economics of production, marketing and processing of soybean in Vidharba region of Maharashtra. Unpublished Ph.D. thesis submitted at MPKV: Rahuri, 2008.
7. M. Asmatoddin S. V. Jawale, D. S. Perke. Economic analysis of pulses on medium farms in Marathwada region of Maharashtra. *Agriculture update*. 2009; 4 (3/4), 262-265.
8. K. S. Birari. Resource use structure, resource productivities and allocation efficiency on farms of western Maharashtra. 1997.
9. S.D. Suryawanshi. Resource use structure and allocation efficiency of bajra cultivation in western Maharashtra. Unpublished M.Sc.(Agri) thesis submitted to MPKV: Rahuri, 1991.
10. K. H. Shapiro, J. Muller. Sources of technical efficiency: The roles of modernization and information. *Economic Development and Cultural Change*. 1977; 25 (2), 293-310.
11. K.R. Sharma, P. S. Leung. H.M. Zaleski. Technical allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and non-parametric approaches. *Agricultural Economics*. 1999; 20(1), 23-25.

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Cite this article as:

V.A. Shinde, D.B. Yadav, S.D. Patole. Assessment of Techno-economic and Allocative efficiencies of maize in Western Maharashtra through Data envelopment analysis. *Indian Journal of Economics and Development*. Vol 3 (5), May 2015.