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Impact of mechanization on cost reduction, yield, profitability and drudgery in paddy cultivation

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Abstract

Objectives: To assess the impact of different degrees of mechanization on yield and profitability of paddy. **Methods/Statistical analysis**: A total of 71 paddy farms were selected from Shimoga district of Karnataka in India and post stratified into less mechanized, moderately mechanized and highly mechanized based on number of operations mechanized. Primary data pertaining to labour, material inputs, output and their prices were elicited using interview schedule for 2016-17. Tabular presentation and budgeting techniques were used to estimate economics and energy use efficiency was computed using relevant ratios.
Findings: The mechanization has resulted in cost reduction to the tune of 24.22% on HMF and 11.04% on MMF compared to LMF. The reduced dependence on human labour was around 47.93 percent on HMF and 28.50% on MMF compared to LMF. HMF and MMF realized additional yield of 4.96q and 2.33q, respectively over LMF. The percent rise in net returns was to the tune of 130.45% on HMF and 47.26% on MMF compared to LMF. HMF was found to be efficient and productive in terms of energy use in paddy cultivation compared to MMF and LMF. **Application/Improvements:** Government should promote mechanization through establishment of custom hiring centres in large numbers to enable marginal and small farmers to avail its benefit at affordable rates.
***Keywords*:** Mechanization, Profitability, Paddy, Yield, Drudgery.

1. Introduction

Paddy cultivation has become difficult in the recent days due to acute scarcity of labour. Paddy being highly labour intensive crop demands around 45 man days of human labour to perform timely operations. Due to acute labour scarcity, paddy growers have shown a transition in cropping pattern from paddy to areca nut requiring relatively less human labour for its management. This sort of transition has got severe implication on food and fodder security. This inturn affects the interest of various stakeholders such as consumers, government, mill owners etc. Paddy is considered as major food crop in Shimoga district. It has been observed that area under paddy is decreasing at the rate of 2.88% every year owing to labour shortage. The problem of labour scarcity can be addressed by mechanizing the farm operation through invention of suitable farm machineries. The small and marginal farmers cannot afford to own machineries or equipment due to lack of their own financial resources. Hence, they look for external assistance to mechanize their farms. The external players are private individuals (large farmers) and government sponsored custom hiring service centres. Private individuals provide mechanical services at relatively higher rates compared to custom hiring service centres. Invention of machineries such as paddy transplanted, cono weeder and combined harvester cum thresher have brought in marked changes in production of paddy. Both the private players and CHSCs have made these machineries available to all categories of farmers. Though, previous studies have highlighted economic impact of mechanization in paddy cultivation but their focus was restricted to few operations. In this study, a modest attempt has been made to capture the economic impact of mechanization of all possible operations in paddy cultivation. Accordingly, sample farms were divided into highly mechanized, moderately mechanized and less mechanized farms based on the extent of mechanization. More precisely, study emphasizes to assess impact of mechanization on yield, cost reduction, profitability and drudgery in paddy cultivation. In addition, energy utilization and production, energy use efficiency, energy productivity and identification of cheaper energy source in paddy cultivation was also assessed.

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2. Methodology

A sample of 71 farmers cultivating paddy was selected from Shimoga district, representative of Malnad region of Karnataka. The sample farms were post stratified as highly mechanized farms (HMF), moderately mechanized farms (MMF) and less mechanized farms (LMF) based on degree of mechanization adopted in paddy cultivation [1]. Farms where land preparation, transplanting, harvesting and threshing operations are mechanized were considered as HMF. MMF are those farms where land preparation, harvesting and threshing operations are mechanized and on LMF only land preparation and threshing operations are mechanized. The primary data pertaining to operation wise use of machines, labour use pattern and material inputs used in paddy cultivation was elicited from farmers using pretested schedule through personal interview method for the agricultural year 2016-17. The source of mechanization and rental charges levied on various mechanical services was obtained. In order to estimate the input energy and output energy of paddy cultivation, the energy equivalents of human labour, machine labour, bullock labour and material inputs such as seeds, fertilizers (NPK), FYM, plant protection chemicals and weedicide was obtained from published sources. Tabular and budgeting techniques were used to estimate economics of paddy cultivation across sources and degrees of mechanization. Energy use indicators such as energy efficiency, energy productivity, specific energy, net energy, profit per MJ, cost per MJ of energy and other related ratios were estimated using relevant formulae [2-4].

Energy use efficiency = $\frac{\text{Out put energy (MJ/acre)}}{\text{Input energy (MJ/acre)}}$

Energy use efficiency: $\frac{\text{Input energy (MJ/acre)}}{\text{Output energy (MJ/acre)}}$

Specific energy or Energy intensity (MJ/kg) : $\frac{\text{Input energy (MJ/acre)}}{\text{Crop yield (kg/acre)}}$

Energy productivity (kg/MJ): $\frac{\text{Crop yield (kg/acre)}}{\text{Input energy (MJ/acre)}}$

Net energy: $\text{Output energy (MJ/acre)} - \text{Input energy (MJ/acre)}$

Cost per MJ of input energy: $\frac{\text{Total cost per acre}}{\text{Total input energy (MJ/acre)}}$

Returns per MJ of input energy: $\frac{\text{Total returns per acre}}{\text{Total input energy (MJ/acre)}}$

Profit per MJ of input energy: $\frac{\text{Net returns per acre}}{\text{Total input energy (MJ/acre)}}$

3. Results and Discussion

1. Cropping pattern

The cropping pattern of sample farmers is presented in Table 1. The farmers are growing paddy on their farm lands to an extent of 26.89% during kharif season and 11.21% during summer season.

Table 1. Cropping pattern of sample farmers

	Crops	Area	Proportion of GCA
Kharif	Paddy	223	26.89
	Maize	35.50	4.28
	Sub total	258.50	31.17
Rabi	Jowar	3	0.36
	Sub total	26	3.13
Summer	Paddy	93	11.21
	vegetables	2	0.24
	Sub total	21.50	2.59
Perennials	Arecanut	504.40	60.82
	Coconut	16	1.93
	Mango	3	0.36
	Sub total	523.40	63.11
	Gross cropped area	829.40	100.00
	Net cropped area	520.20	
	Cropping intensity	159.43	

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About 63% of the gross cropped area was under perennials. Among perennials, areca nut enjoyed the lion share. The result clearly depicts the apparent transition in cropping pattern from paddy to areca nut in Malnadu region. This indicates that farmers cultivate paddy as a food crop to meet their family food requirements and areca nut for generating cash income.

2. Extent of mechanization

Farmers of the study area have been practicing mechanization in paddy cultivation in varied degrees depending upon the availability of machines and equipment. It is observed from the Table 2 that farmers are categorized into three categories based on the degree of adoption as HMF, MMF and LMF. HMF constitutes 46.47% of the total sample. These are the operations for which machineries are available and innovative farmers have made use of them to the fullest extent. MMF has adopted machineries for completing operations such as land preparation, harvesting and threshing. Their number is 27 accounting for 38% of the total sample. LMF have mechanized only two operations namely land preparation and threshing and constituted 15.49% of the total sample.

Table 2. Extent of mechanization in paddy

Extent of mechanization	Operations mechanized	Number of sample farmers
HMF	Land preparation, Transplanting, Harvesting, Threshing	33(46.47)
MMF	Land preparation, Harvesting, Threshing	27(38.02)
LMF	Land preparation, Threshing	11(15.49)

3. Operation wise mechanization

The perusal of Table 3 indicates that percent of sample farmers have mechanized land preparation and threshing operations in paddy followed by 84% in harvesting. About 46% of paddy farmers have gone-in for mechanized transplanting. Acute labour scarcity is the main reason prompting the farmers to go in for mechanization. Besides, readily available machines in the local area are another reason which has motivated the farmers to adopt mechanization for land preparation, harvesting and threshing operations. Adoption of transplanting machine to perform transplanting operation is yet to pick up in paddy because farmers are not completely convinced about the benefits of transplanting machine. Though, the machineries are made available by CHSCs, the farmers are under the apprehension that transplanting by machine could not ensure required plant population per unit area. Lack of knowledge among paddy growers about preparation of special nursery bed has contributed to this. This reflects the role of extension personnel and line departments in educating farmers about nursery bed preparation and economic benefits of mechanized transplanting through method demonstration and training programmes.

Table 3. Operation wise mechanization in Paddy (n=71)

Operations	Number
Land preparation	71(100)
Transplanting	33(46.47)
Harvesting	60(84.5)
Threshing	71(100)

4. Economics of paddy cultivation across different degrees of mechanization

Table 4 indicates the economics of mechanization in paddy cultivation across different degrees of mechanization. It may be observed that the operational cost of paddy cultivation was highest at ₹26212.02 in case of LMF followed by ₹23106.51 in case of MMF. The HMF had incurred least cost of cultivation of ₹19862.52. Mechanization has contributed towards cost reduction to an extent of ₹6349.50 (24.22%) in case of HMF and ₹3105.51 (11.04%) in case of MMF as compared to LMF. Mechanization has reduced dependence on human labour to an extent of 19.93 man days (47.93%) and 11.85 man days (28.50%) in case of HMF and MMF, respectively in comparison with LMF. Thus, mechanization has not only reduced cost of cultivation but also resulted in reduced drudgery [5]. With regard to grain yield, increased yield of 4.96 q (23.50%) and 2.33 q (11.04%) was observed in case of HMF and MMF as compared to LMF. The net returns of HMF have realized highest net returns of ₹19965 followed by MMF at ₹12757.95 and LMF at ₹8663.37. Profits could be boosted on HMF and MMF to an extent of 130.45% and 47.26%, respectively as compared to LMF.

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Table 4. Economics of mechanization in paddy (Rs. /acre)

Particulars	HMF			MMF			LMF		
	Qty	Rate (Rs.)	Value (Rs.)	Qty	Rate (Rs.)	Value (Rs.)	Qty	Rate (Rs.)	Value (Rs.)
Machine labour(h)									
a) Bed preparation	1	463	463	0.66	1000	660	0.5	1000	500
b) Land preparation									
i) Cultivator	1.65	533.00	879.45	2.42	566.66	1371.31	2.04	609.09	1242.544
ii) Cage wheel	4.60	427.00	1964.2	4.5	529.63	2383.33	4.27	500	2135
c) Transplanting	2.56	695.00	1779.2						
d) Harvesting & threshing	1.55	1493.00	2314.15	1.41	1577.78	2224.66			
e) Threshing							1.86	600	1116
Subtotal	11.36		7400.00	8.99		6639.32	8.67		4993.54
Human labour (man days)									
a) Bed preparation	1.45	300.00	435	1.96	300	588	2	300	600
b) Bunding	3.41	300.00	1023	3.77	300	1131	4.09	300	1227
c) Transplanting				4.47	400	1788	4.86	400	1944
d) Fertilizer application	2.06	300.00	618	2.25	300	675	2.34	300	702
e) Weeding	4.36	300.00	1308	4.99	300	1497	4.59	300	1377
f) Weedicide application	1.00	300.00	300	1	300	300	1	300	300
g) PP Chemical application	1.00	300.00	300	1	300	300	1	300	300
h) Irrigation	3.54	300.00	1062	4	300	1200	4.7	300	1410
i) Harvesting							10	350	3500
j) Bundling	4.83	300.00	1449	6.29	300	1887	7	300	2100
Subtotal	21.65		6495.00	29.73		9366.00	41.58		13460.00
Bullock labour (Pair days)									
a) Leveling	1.00	924.00	924	1	1088.89	1088.89	1	1110	1110
Subtotal			924			1088.89			1110
Inputs									
1 Tarpel	1.00	156.00	156						
2.FYM									
3. Seeds(Kg)	14.07	31.65	445.3155	24.92	37.32	930.01	25	38	950
4. Fertilizer									
i) Nursery	4.21	20.00	84.2	4.92	20	98.4	4.27	20	85.4
ii)Main field (50 Kg bag)									
a)DAP	0.96	1200.00	1152	1.2	1200	1440	1.34	1200	1608
b)Urea	0.66	300.00	198	0.76	300	228	1	300	300
c)Potash	0.69	900.00	621	0.73	900	657	1.04	900	936
d)Complex	1.02	1000.00	1020	1	1000	1000	0.81	1000	810
5.Weedicide			608.00			675.55			704.54
6.PPC			759.00			983.33			1254.54
Subtotal			5043.52			6012.29			6648.48
Total cost (Rs.)			19862.52			23106.51			26212.02
Yield (Qtl.)			26.07			23.44			21.11
Price			1413.33			1413.33			1413.33
Returns from main product			36845.51			33128.46			29835.4
By-Product in bundles	248.50	12.00	2982.00	228	12	2736	420	12	5040
Gross returns			39827.51			35864.46			34875.4
Net returns			19965.00			12757.95			8663.373

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5. Energetics of paddy cultivation

Table 5 outlines details of input and output energy in paddy cultivation. It shows that mechanical input energy was in the order of 1313.64 MJ, 1254.46 MJ and 1127.46 MJ, respectively in case of HMF, MMF and LMF. The human energy was found to be the lowest in HMF compared to other two situations obviously due to replacement of human labour by mechanical devices. With regard to bullock labour, it may be seen that only one pair-day of bullock labour was used in all the situations mainly for leveling of paddy field. Leveling by bullock labour brings land to fine tillage for transplanting.

Table 5. Details of input and output energy in paddy cultivation

Particulars/Extent of mechanization		HMF			MMF			LMF		
	Energy equivalents (MJ)	Qty /acre	Total Energy Requirement (TER)	Share in Total input energy (%)	Qty /acre	Total Energy Requirement (TER)	Share in Total input energy (%)	Qty /acre	Total Energy Requirement (TER)	Share in Total input energy (%)
A. Input Energy										
a) Machine labour										
1)Cultivator(h)	3.14	2.65	8.32	0.17	3.08	9.67	0.18	2.54	7.98	0.14
2) Pudddling (h)	2.51	4.60	11.54	0.23	4.50	11.29	0.21	4.27	10.71	0.19
3) Tractor (h)	62.70	7.25	454.58	9.10	7.58	475.27	8.67	6.81	426.99	7.51
4) Transplanting (h)	0.91	2.56	2.33	0.05						
7) Harvesting & Threshing (h)	47.03	1.55	72.90	1.46	1.41	66.31	1.21			
8) Threshing (h)	7.52							1.86	13.99	0.25
9) Fuel (L)										
a) Petrol	48.23	1.79	86.43	1.73						
b) Diesel	51.33	13.20	677.56	13.57	13.48	691.93	12.62	13.01	667.80	11.74
Sub total			1313.64	26.31		1254.46	22.87		1127.46	19.82
b)Human labour(h)	1.96	173.20	339.47	6.80	237.84	466.17	8.50	332.64	651.97	11.46
Sub total			339.47	6.80		466.17	8.50		651.97	11.46
c)Bullock labour(pair days)	64.56	1.00	64.56	1.29	1.00	64.56	1.18	1.00	64.56	1.13
Sub total			64.56	1.29		64.56	1.18		64.56	1.13
d) Materials										
1)Seeds(kg)	14.70	14.07	206.83	4.14	24.92	366.32	6.68	25.00	367.50	6.46
2) FYM (kg)										
3)Fertilizer(kg)										
a)Nitrogen	66.14	28.92	1912.77	38.31	33.28	2201.14	40.13	39.11	2586.74	45.47
b)Phosphate	12.44	35.34	439.63	8.80	40.60	505.06	9.21	41.35	514.39	9.04
c)Potassium	11.15	33.96	378.65	7.58	34.90	389.14	7.09	41.73	465.29	8.18
4)Weedicide(L)	238.00	1.00	238.00	4.77	1.00	238.00	4.34	1.00	238.00	4.18
5)Plant protection chemicals(L)	199.00	0.50	99.50	1.99	0.50	99.50	1.81	0.50	99.50	1.75
Sub total			3275.38	65.60		3799.16	69.27		4271.42	75.09
Total input energy			4993.06	100.00		5484.85	100.00		5688.43	100.00
B.Output Energy										
Paddy grain yield (kg)	14.70	2607.00	38322.90	67.28	2344.00	34456.80	66.83	2111.00	31031.70	49.63
Paddy straw yield (kg)	12.50	1491.00	18637.50	32.72	1368.00	17100.00	33.17	2520.00	31500.00	50.37
Total output energy			56960.40	100.00		51556.80	100.00		62531.70	100.00

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The amount of energy required for this operation was 64.56 MJ. The energy from material sources in paddy cultivation included seeds, fertilizers, FYM, plant protection chemicals, which together contributed 3275.38 MJ, 3299.16 MJ and 4271.42 MJ, respectively in case of HMF, MMF and LMF. The total of input energy contributed by all the sources was estimated to 4993.6 MJ, 5484.85 MJ and 5688.43 MJ in HMF, MMF and LMF, respectively indicating LMF depended more on human energy and used higher quantity of inputs. The output energy was found to be higher in case of LMF due to higher straw yield as LMF harvest paddy with human labour and as such there is no loss of straw whereas in case of HMF and MMF substantial amount of fodder was lost due to mechanical harvesting.

6. Energy indicators

Energy indicators given in the Table 6 revealed that paddy cultivation required input energy of 4993.6 MJ, 5484.85 MJ and 5688.43 MJ across HMF, MMF and LMF situations. The HMF have been able to obtain 26.07 q of grain yield as against 23.44 q and 21.11 q in case of MMF and LMF, respectively yielding output energy of 56960.40 MJ, 51556.80 MJ and 62531.70 MJ.

The energy use efficiency was found to be highest at 11.41 in HMF. The productivity gain per unit of MJ was also highest in HMF at 0.52 kg/MJ as compared to 0.43 kg and 0.37 kg/MJ in MMF and LMF. The total cost of cultivation was lower in HMF as compared to the rest. Similarly, the gross returns and net returns were also found to be higher in case of HMF. The profit per MJ of input energy worked out to ₹4 on HMF while ₹2.83 and ₹1.52 on MMF and LMF. All the above measures indicated that mechanization in paddy has yielded positive results encouraging the paddy growers to adopt machines and reap the benefits.

Table 6. Energy indicators in paddy cultivation

Sl.No.	Particulars/Extent of mechanization	HMF	MMF	LMF
1	Total output energy (MJ)	56960.40	51556.80	62531.70
2	Total input energy (MJ)	4993.06	5484.85	5688.43
3	Paddy Yield in Kg/ acre	2607.00	2344.00	2111.00
4	Energy use efficiency (1/2)	11.41	9.40	10.99
5	Specific energy in MJ/Kg (2/3)	1.92	2.34	2.69
6	Energy productivity in Kg/MJ (3/2)	0.52	0.43	0.37
7	Net energy in MJ (1-2)	51967.34	46071.95	56843.27
8	Total cost per acre (Rs.)	19862.52	23106.51	26212.02
9	Gross returns per acre (Rs.)	39827.51	35864.46	34875.40
10	Net returns per acre (Rs.)	19965.00	12757.95	8663.37
11	Cost per MJ of input energy in Rs. (8/2)	3.98	4.21	4.61
12	Returns per MJ of input energy in Rs. (9/2)	7.98	6.54	6.13
13	Profit per MJ of input energy in Rs. (10/2)	4.00	2.33	1.52

7. Cost of input energy

Valuation of energy from different sources was estimated and presented in Table 7. This indicated the mechanical source of energy was cheaper compared to human and bullock labour at ₹5.75 /MJ, ₹5.29 and ₹4.42 /MJ respectively on HMF, MMF and LMF. Human energy source was highly expensive at ₹20/MJ across all the three situations and similar was the situation in case of bullock labour energy (₹14 to ₹17/MJ).

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Table 7. Cost of input energy across different sources

Source of input energy/ Extent of mechanization	HMF			MMF			LMF		
	Cost (Rs.)	Total energy equivalents (MJ)	Cost/ MJ of energy (Rs.)	Cost (Rs.)	Total Energy equivalents (MJ)	Cost/ MJ of energy (Rs.)	Cost (Rs.)	Total energy equivalents (MJ)	Cost/ MJ of energy (Rs.)
Machine labour	7594.86	1318.64 (76.67)	5.75	6639.32	1254.46 (70.27)	5.29	4993.54	1127.46 (61.14)	4.42
Human labour	6438.00	336.49 (19.56)	19.13	9366.00	466.17 (26.11)	20.09	13460.00	651.97 (35.35)	20.64
Bullock labour	926.19	64.56 (3.75)	14.34	1088.89	64.56 (3.61)	16.86	1110.00	64.56 (3.50)	17.19
Total labour	14959.05	1719.69 (100)	39.24	17094.21	1785.19 (100)	42.25	19563.54	1844.00 (100)	42.27
Materials	3275.38	5043.52	0.64	3799.16	6012.29	0.63	4271.42	6648.48	0.64

4. Conclusion

The economic impact of mechanization on paddy cultivation was assessed considering a sample of 71 farmers from Shimoga district of Karnataka. The farms were categorized into HMF, MMF and LMF based on the extent of mechanization. Sample farms comprised of 46.47% of HMF and 15.49% of LMF. The mechanization has resulted in cost reduction to the tune of 24.22% on HMF and 11.04% on MMF compared to LMF. The reduced dependence on human labour was around 47.93 percent on HMF and 28.50% on MMF compared to LMF. HMF and MMF realized additional yield of 4.96 q and 2.33 q, respectively over LMF. The percent rise in net returns was to the tune of 130.45 percent on HMF and 47.26% on MMF compared to LMF. HMF was found to be efficient and productive in terms of energy use in paddy cultivation compared to MMF and LMF. The mechanical energy was found to be the cheapest source of energy at ₹5/MJ compared to human and animal energy. Hence, it is advisable to the farmers to adopt mechanization to reap tangible (cost reduction and increased net returns) and intangible benefits (drudgery and performance of timely farm operations). The extension machinery and line departments should take this message to paddy growers and convince them about economic benefits of mechanization.

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