SOURCES OF GROWTH OF RETURNS IN PADDY CULTIVATION UNDER NATURAL FARMING V/S CONVENTIONAL FARMING: AN ECONOMIC ANALYSIS

ABSTRACT

Aim: This study aims to analyze the economics of paddy cultivation under natural farming and conventional farming systems and seeks to provide insights into the profitability and cost-efficiency of natural farming while identifying the factors contributing to differences in net returns between the two methods.

Study design: Purposive multistage random sampling technique was employed to select districts, mandals, villages, and various stakeholders. The primary data collection was based on a total sample of 80 farmers, comprising 40 natural farmers and 40 conventional farmers from four villages across two mandals and two districts.

Place and Duration of Study: The study was taken up in Parvathipuram Manyam and Alluri Seetha Ramaraju districts of North coastal region of Andhra Pradesh during the agriculture year 2022-23.

Methodology: To study the economics of paddy grown under natural and conventional farming, cost and return analysis was taken up and Bisaliah's Output Decomposition Model was used to study the sources contributing to difference in net returns between two groups.

Results: The cost of cultivation per acre of paddy was found to be 15 per cent higher in conventional farming (Rs. 47,503.89) compared to natural farming (Rs. 40,164.98) which was majorly due to the differences in material cost. The cost of production per quintal of paddy was lower in conventional farming (Rs. 1,898.64) than natural farming (Rs. 2,042.98). The operational costs such as costs incurred on human labour were found to be higher in case of naturally grown paddy. The gross returns from conventional farming (Rs. 60,234.44) were about six per cent higher than natural farming (Rs. 56,398.33) but, the net returns from natural farming (Rs. 16,224.35) were 27 per cent higher than conventional farming (Rs, 12,730.54). The returns per rupee of expenditure was also found to be higher in natural farming (1.40) than conventional farming (1.27) exclusively attributable due to reduced costs in natural farming in spite of underproduction. The total observed difference in net returns was 25.98 per cent, reflecting the overall benefit of adopting natural farming practices over conventional farming. The breakdown of sources of increase in net returns consists of two major components i.e., the technology component and the input contribution. The technology component, accounted for 20.25 per cent of increase in net returns and inputs contributed to the extent of 5.73 per cent with varied contributions from different inputs.

Conclusion: Natural farming demonstrates economic advantages over conventional farming despite lower yields, primarily due to reduced material costs. While gross returns were higher in conventional

farming, natural farming achieved 27 per cent higher net returns and higher returns per rupee of expenditure. The increased net returns from natural farming was largely driven by technological improvements and optimized input usage.

Keywords: Natural farming, Paddy, Cost, returns, Gana Jeevamrutham, Dhrava Jeevamrutham and output decomposition.

1. INTRODUCTION

The Green Revolution saw the liberal application of inorganic fertilizers and chemicals and is believed to have significantly contributed to sustained food security in many developed and developing countries. Its strategies paid rich dividends in India, with a phenomenal increase in food grain production from 115.6 million tonnes in 1960-61 to over 281.37 million tonnes in 2018-19 (Praduman *et al.* 2016). Similarly, annual consumption of N, P and K fertilizers increased from 0.07 million tonnes in 1951-52 to more than 25.95 million tonnes in 2016-17 (Bagal *et al.* 2018). According to the Annual Report 2017-18, Ministry of Agriculture and Farmers' Welfare, a 50 per cent rise in food grain production can be attributed to increased fertilizer consumption. However, the Green Revolution with its excessive use of fertilizers led to an imbalance in soil health (Patra *et al.* 2016) by destroying useful soil microflora. The heavy reliance on chemical fertilizers and pesticides has not only led to declining soil health and stagnant crop productivity but also pushed many farmers into a cycle of debt due to escalating production costs and unstable market conditions. Moreover, these chemicals pose serious health risks to both farmers and consumers.

Natural farming offers a sustainable solution by working in harmony with nature's laws, leveraging the inherent biodiversity of each farming ecosystem. Unlike conventional methods, it fosters a balanced ecosystem where plants, animals, and microorganisms coexist and support each other. This approach emphasizes the importance of the interplay between plant and animal life to enhance soil fertility and promote beneficial microorganisms (Smith *et al.* 2020). This farming practice is characterized by its low-input and low-risk, making it a climate-resilient alternative. Natural farming stands as a significant shift from the high external input model of the Green Revolution to a cost-effective farming practice (Babalad *et al.* 2021).

The core principle underlying the natural farming is the usage of jeevamrutha and beejamrutha. Jeevamrutha is a fermented mixture of cow dung, cow urine, jaggery, pulse flour, and bund soil, serves as a potent bio-stimulant that boosts the activity of soil and plant-associated microorganisms. Beejamrutha, which is essentially jeevamrutha without water, is used for treating seeds to promote healthy plant growth. Additional practices include bio-mulching (Acchadana), intercropping, and the use of indigenous seeds. Natural farming also promotes the use of homemade bio-pesticides like neemastra, agniastra, and bramhastra, which are effective against a wide range of pests and diseases. These practices contribute to soil health by enhancing microbial diversity and increasing soil organic matter (Khan *et al.* 2022).

States such as Andhra Pradesh, Himachal Pradesh, Gujarat, Haryana, Karnataka and Kerala are promoting natural farming. Andhra Pradesh is the front runner among all states in implementing

natural farming Programme at a mass scale. According to the Andhra Pradesh government, as of March 2020, 0.62 million farmers (10.5 %) were enrolled in the Programme. Out of which, 0.44 million farmers (7.5 %), were actually practicing natural farming on an area of 0.45 million acres, which works out to 2.9 per cent of the net sown area spread across 3,011 numbers of gram panchayats. Karnataka also initiated implementation of natural farming on a pilot basis in 2,000 hectares in each of the ten agro-climatic zones of the state. Only a few farmers have been doing it at individual scale in other states. Himachal Pradesh has initiated the Prakritik Kheti Khushal Kisan since May 2018 to promote natural farming in the state. Kerala, Gujarat, Haryana and Rajasthan have conducted multiple mass level awareness programmes, trainings and workshops for hundreds and thousands of farmers to promote natural farming (Sharma *et al*. 2023).

In 2016, the Agriculture Department, Government of Andhra Pradesh initiated the Programme that was called “Andhra Pradesh Zero Budget Natural Farming” (APZBNF) which is recently changed to “Andhra Pradesh Community Natural Farming” (APCNF). This sustainable method is intended to benefit farmers, consumers, and the environment, making agriculture more viable and sustainable for future generations. They have successfully transformed about six million farmer households, two million farm worker households and six million ha of farmland to adopt natural farming practices (2022-23).

This present study examines the economics of paddy cultivation under natural and conventional farming practices, providing valuable insights into the profitability and cost-efficiency of natural farming. By analyzing output differences between the two methods, the research evaluates whether natural farming can sustainably achieve competitive yields, offering critical guidance for farmers considering this transition.

2. MATERIAL AND METHODS

2.1 Sampling design

The purposive multistage random sampling technique was employed for the selection of districts, mandals, villages and farmers. The study focused on the top two districts that were having highest area under natural farming cultivation for the purpose of sampling (Fig. 1). Within each chosen district, one mandal was purposively selected, and subsequently, the two villages in each selected mandal were identified for survey. In the final stage, twenty farmers were chosen from each village comprising of 10 Farmers Practicing Natural Farming (FPNF) and 10 Farmers Practicing Conventional Farming (FPCF). Thus, a total sample size of 80 farmers (40 FPNF and 40 FPCF from 4 villages of two mandals and two districts), formed basis for collection of primary data related to the agriculture year 2022-23. Various practices of natural farming being taken up in the state were broadly classified in to four categories (Fig. 1).

The practices include:

1. C1 - Farmers taking up at least any one practice related to natural farming fall under the category of C1.

2. PMDS – PMDS represents Pre Monsoon Dry Sowing, in this category farmers take up the sowing practice before the arrival of monsoon season.

3. S2S – S2S represents Seed to Seed. In this category all the practices from sowing to harvesting are done on par with the specified natural farming standard practices.

4. S2S-W – S2S-W represents Seed to Seed Whole. In this category all the practices from sowing to harvesting are done on par with the specified natural farming standard practices and the whole acreage of land the farmer holds is under natural farming.

The North coastal region of Andhra Pradesh was purposively selected for the study due to its high crop diversity under natural farming. Within this region, two districts *viz.,* Parvathipuram Manyam, and Alluri Sitharama Raju were chosen purposively, as they had the highest area under natural farming (Fig.1).

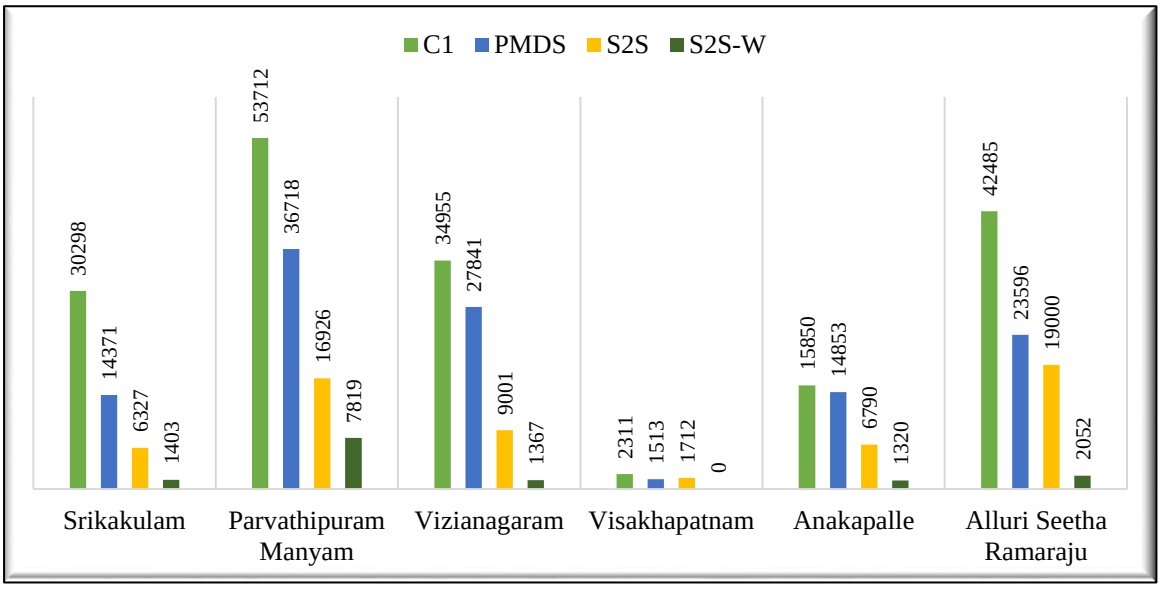

Fig. 1: Area under natural farming in different districts of North Coastal Region of Andhra Pradesh (acres)

Source: Department of Agriculture, Andhra Pradesh, 2022-23.

Table 1 provides details about the selected districts, mandals, villages, and paddy farmers in the North Coastal region of Andhra Pradesh. The study covered two districts, Parvathipuram Manyam and Alluri Seetha Ramaraju, and included a total sample size of 80 farmers, equally distributed between Farmers Practicing Natural Farming (FPNF) and Farmers Practicing Conventional Farming (FPCF). In Parvathipuram Manyam, the study was conducted in the Garugubilli mandal, focusing on the villages of Pittalametta and Kothuru. The sample size consisted of 20 paddy farmers from each village, with 10 farmers practicing natural farming and 10 farmers practicing conventional farming. In Alluri Seetha Ramaraju district, the study took place in the Dumriguda mandal, specifically in the villages of Kinchumanda and Dumriguda. Here too, the sample size included 20 farmers from each village, divided equally between the two farming practices. In total, 40 paddy farmers practicing natural farming and 40 farmers practicing conventional farming constituted the sample size.

Table 1: Particulars of the selected districts, mandals, villages and farmers in North coastal region of Andhra Pradesh

Sl. No.	District	Mandal	Village	Sample size	
				FPNF	FPCF
1	Parvathipuram Manyam	Garugubilli	Pittalametta	10	10
			Kothuru	10	10
2	Alluri Seetha Ramaraju	Dumriguda	Kinchumanda	10	10
			Dumriguda	10	10
	Total			**40**	**40**

Note: FPNF - Farmers Practicing Natural Farming and FPCF - Farmers Practicing Conventional Farming

2.2 Analytical tools and techniques

2.2.1 Cost concepts

Costs and returns concepts were used to study the profitability of cultivation of paddy grown under natural and conventional conditions. The total costs were classified into variable and fixed costs

I. Variable costs: These are the costs incurred on labour, material or inputs used and interest on working capital.

i. Labour cost: The expenditure incurred on human labour, bullock labour, and machine labour together constituted the labour costs.

ii. Material/ input costs: They include expenditure on seeds, fertilizers, plant protection chemicals, etc. The material or inputs used were different in case of natural and conventional farmers are mentioned under different headings below.

Material costs in natural farming include costs incurred on main seed, trap crop seed, navadanya, beejamrutha, gana jeevamrutha, dhrava jeevamrutha, plant protection astras (neemastra, bramhastra, agniastra, tutikada kashaya, dashaparni kashaya etc..), natural growth promoters (panchagavya, sour buttermilk and similar liquids), azolla and pseudomonas, electricity charges and irrigation and in conventional farming the material costs include costs incurred on seed, Farm Yard Manure (FYM), fertilizers, plant protection chemicals, electricity charges and irrigation.

iii. Interest on working capital: The interest on working capital was calculated at the rate charged by institutional agencies, which is generally seven per cent per annum apportioned for the crop duration.

II. Fixed costs: These costs include depreciation on farm implements and machinery, rental value of land, land revenue and interest on fixed capital

i. Rental value of land: It was taken at the rate prevailing in the study area on yearly basis for the crop duration.

ii. Land revenue: The land revenue was charged at rates levied by the government.

iii. Interest on fixed capital: This includes interest on the book value of asset/livestock and is calculated at 12 per cent per annum.

iv. Depreciation: Depreciation on each owned capital equipment and machinery used by the farmers was calculated separately using the straight-line method.

$$\text{Annual depreciation} = \frac{\text{Purchase value – Junk value}}{\text{Economic life of the asset}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The marketing charges incurred by respondents in marketing of the study crops were also considered which includes costs incurred on cleaning, packaging, packing material cost, loading, unloading, transportation costs and commission charges.

Cost of cultivation

The cost of cultivation is the sum of variable costs and fixed costs and expressed on per acre basis.

2.2.2 Returns concepts

1. Gross returns: Per acre gross returns were calculated by using the below formula.

Gross Returns (GR) = Yield per acre * Selling price……(2)

2. Net returns: It is the Gross Returns minus total cost of cultivation which include Total Variable Costs and Total Fixed Costs

Net returns over cost of cultivation = GR- TC (TVC+TFC) ……(3)

3. Returns per rupee of expenditure: It is worked out by dividing gross returns with the total cost of production.

2.2.3 Bisaliah's Output Decomposition Model

The Output Decomposition Model, developed by Dr. S. Bisaliah in 1977, was designed to estimate the sources of output growth resulting from the adoption of new technologies. In the present study, the Output Decomposition Model was primarily used to identify the sources of output (income or returns) growth resulting from the adoption of natural farming compared to conventional farming. This model provides valuable insights into the contribution of new technology i.e., natural farming to increased output (returns), termed as the "technology contribution," which is instrumental in evaluating the returns on investment in research and development.

Considering the differences in crops and their varieties among the farmers, net returns and input usages per acre in monetary terms were used for functional analysis. For accomplishing the task of decomposition analysis, the following form of Cobb-Douglas type of production function has been used:

$$Y = A\, S^{b1}\, HL^{b2}\, ML^{b3}\, M^{b4}\, F^{b5}\, P^{b6}\, I^{b7}\, U_1 \quad \ldots\ldots\ldots\ldots (4)$$

Where,

Y = Net returns (Rs.)

A = Intercept

S = Seeds (kg/acre)

HL = Human labour (md/acre)

ML = Machine hours (hrs/acre)

M =Gana Jeevamrutham /Manures (q/acre)

F = Dhrava Jeevamrutham/ Fertilizers (l or kg/acre)

P =Plant protection astras/ Plant protection chemicals (l/acre)

I = No. of irrigations (no./acre)

b_i = Production coefficients for i=1 to n (no. of variables)

U =Error terms

Then $\sum b_i$ indicates the returns scale, coefficients were tested for their significance using 't' test, while the model was tested using the 'F' tests (Goodness of Fit) at chosen level probability.

The structural break in the production relations is essential before going for decomposition analysis of output difference and was estimated using the dummy (binary) variable technique by assigning value '1' for farmers practicing natural farming and '0' (zero) for farmers practicing conventional farming for the pooled data set of both the category of farms irrespective of the situation. The following type of function was used for the purpose.

$$Y = A\, S^{b1}\, HL^{b2}\, ML^{b3}\, M^{b4}\, F^{b5}\, P^{b6}\, I^{b7}\, D^{d}\, U_1 \quad \ldots\ldots\ldots\ldots (5)$$

Where,

D-Dummy variable and rest of the variables are same as defined earlier.

The above equation was converted into log-linear form by taking 'ln' on both the sides and the parameters (coefficients) were estimated using the Ordinary Least Squares (OLS) method as follows.

$$\text{Ln } Y = \ln A + \ln S^{b1} + \ln HL^{b2} + \ln ML^{b3} + \ln M^{b4} + \ln F^{b5} + \ln P^{b6} + \ln I^{b7} + \ln D^{d} + U_1 \quad \ldots\ldots (6)$$

If the estimated coefficient of dummy variable found to be significant, then that indicates the structural break in production relations between the two categories of farms, and this offers required justification to go for decomposition of output difference and estimate sources of output difference. After testing the structural break in the production relations between the two situations, the following production functions were estimated separately for the two categories of farms by plugging the estimated parameters, quantities of output and inputs into decomposition model for estimating the different sources contributing to the output differences.

$$\ln Y_N = \ln A_N + \ln S_N^{bN1} + \ln HL_N^{bN2} + \ln ML_N^{bN3} + \ln M_N^{bN4} + \ln F_N^{bN5} + \ln P_N^{bN6} + \ln I_N^{bN7} + U_N$$

..... (7)

$$\ln Y_C = \ln A_C + \ln S_C^{bC1} + \ln HL_C^{bC2} + \ln ML_C^{bC3} + \ln M_C^{bC4} + \ln F_C^{bC5} + \ln P_C^{bC6} + \ln I_C^{bC7} + \ln P_C^{bC8} + U_C \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where, subscripts 'N' and 'C' indicates Natural farming and Conventional farming respectively and all other variables are same as defined earlier.

Now the following Bisaliah's output decomposition model as obtained by taking the difference between equation (7) and (8) was used for estimating the differences in output under two situations by plugging the estimated values of different parameters of inputs and geometric mean levels of inputs and dependent variable.

$$\text{Ln } Y_N - \ln Y_C = \{\ln A_N - \ln A_C\} + \{[b_{N1} - b_{C1}]\, S_C + [b_{N2} - b_{C2}]\, HL_C + [b_{N3} - b_{C3}]\, ML_C + [b_{N4} - b_{C4}]\, M_C + [b_{N5} - b_{C5}]\, F_C + [b_{N6} - b_{C6}]\, P_C + [b_{N7} - b_{C7}]\, I_C + \{[\ln S_N - \ln S_C]\, b_{N1} + [\ln HL_N - \ln HL_C]\, b_{N2} + [\ln ML_N - \ln ML_C]\, b_{N3} + [\ln M_N - \ln M_C]\, b_{N4} + [\ln F_N - \ln F_C]\, b_{N5} + [\ln P_N - \ln P_C]\, b_{N6} + [\ln I_N - \ln I_C]\, b_{N7} + \{U_N - U_C\}$$

..... (9)

The decomposition equation (9) represents an approximate measure of the percentage change in net returns between two production scenarios, captured on the left-hand side (LHS) of the equation. On the right-hand side (RHS), the first bracketed term quantifies the percentage change in net returns attributable to shifts in the scale parameter (A) of the production function, indicating how changes in scale affect net returns. The second bracketed term reflects the impact of shifts in the slope parameters (output elasticities) of the production function, calculated as the difference between output elasticities, each weighted by the natural logarithms of the input use level under conventional farming practices. This term measures the change in net returns due to altered responsiveness of output to each input. The third bracketed expression on the RHS captures the sum of the natural logarithms of the input ratios between natural farming practicing farms and conventional farming farms, each weighted by the output elasticity of that input under natural farming. This term represents changes in net returns due to variations in per-acre input quantities—such as seed, human labour, machine labour, gana jeevamrutham/manure, dhrava jeevamrutham/fertilizers, plant protection astras/ chemicals and number of irrigations used under the new technology.

3. RESULTS AND DISCUSSION

3.1 Costs and returns of paddy grown under natural and conventional farming

3.1.1 Economics of paddy grown under natural farming

The details on cost of cultivation of paddy grown under natural farming are presented in Table 2.

Table 2: Cost of cultivation of paddy grown under natural farming

(Per ac)

Sl. No.	Particulars	Quantity	Cost (Rs.)	Per cent
I	**Variable cost**			
A.	**Labour**			
1	Human Labour	54.00	18,073.33	45.00

	a. Women labour (days)	24.50	7,638.33	19.02
	b. Men labour (days)	29.50	10,435.00	25.98
2	Bullock Labour (Pair days)	0.20	181.23	0.45
3	Machine Labour (hours)	4.71	5,160.47	12.85
	Total labour cost		**23,415.03**	**58.30**
B.	**Material costs**			
1	Navadanya (kg)	10.00	631.67	1.57
2	Seeds of main crop (kg)	25.04	862.67	2.15
3	Trap crop seed (kg)	2.05	151.08	0.38
4	Beejamrutham (l)	2.00	27.40	0.07
5	Gana Jeevamrutham (kg)	330.00	605.00	1.51
6	Dhrava Jeevamrutham (l)	861.83	900.83	2.24
7	Plant protection sprays (l)	220.34	1,051.03	2.62
8	Azolla (kg)	5.22	66.78	0.17
9	Pseudomonas	2.00	51.11	0.13
10	Growth promoters(l)	28.29	338.33	0.84
11	Irrigation costs (acre inches)	38 ac inches	2,487.60	6.19
	Total material cost		**7,173.51**	**17.86**
	Total working capital		**30,588.54**	**76.16**
	Interest on working capital @ 7 %		1,070.60	2.67
	Total variable cost		**31,659.13**	**78.82**
II	**Fixed cost (Rs.)**			
1	Land revenue		65.00	0.16
2	Depreciation		1,289.50	3.21
3	Rental value of land		6,240.00	15.54
4	Interest on fixed capital @ 12 %		911.34	2.27
	Total fixed cost		**8,505.84**	**21.18**
III	**Cost of cultivation (Rs/ac)**		**40,164.98**	**100.00**
IV	**Cost of production (Rs/q)**		**2,042.98**	
V	**Marketing cost (Rs/ac)**		**2,100.20**	
	a. Bags (no.s)	25	380.00	
	b. Packaging and transportation		638.90	
	c. Commission charges		1,081.30	

The findings from Table 2 revealed that, farmers incurred a total cost of Rs. 40,164.98/ac in paddy cultivation under natural farming which consisted of, Rs. 31,659.13 total variable cost (78.82%) and Rs. 8,505.84 total fixed cost (21.18%). Among the various items of variable costs, majority of it was comprised of labour costs (58.30%) and material costs (17.86%) which were worked out to be Rs. 23,415.03 and Rs. 7,173.51, respectively. Out of total labour cost, Rs. 18,073.33 was human labour cost (45%), which comprised of Rs. 7,638.33 as expenditure on women labour and Rs. 10,435.00

towards men labour used, while bullock labour (0.45%) and machine labour (12.85%) accounted for Rs.181.23 and Rs. 5,160.47, respectively.

With respect to material cost involved in paddy cultivation under natural farming, it was observed that Rs.631.67 was incurred on navadanya (1.57%), Rs.862.67 was spent for seeds of main crop (2.15%), Rs.151.08 was spent for trap crop seed (0.38%), Rs.27.40 was spent on beejamrutham (0.07%), Rs.605 was incurred on gana jeevamrutham (1.51%), Rs.900.83 was incurred on dhrava jeevamrutham (2.24%), Rs.1051.03 was spent on plant protection sprays (2.62%). Furthermore, Rs.66.78 was spent for azolla (0.17%), Rs.51.11 was spent on pseudomonas (0.13%), Rs.338.33 was spent on growth promoters (0.84%) and Rs. 2,487.60 was spent on irrigation; thus, all the materials used together accounted for Rs. 7,173.51 (17.86%). The total working capital was Rs. 30,588.54 (76.16%) including an interest of Rs. 1,070.60 (2.67%) on variable cost that makes up the total variable cost to Rs. 31,659.13 (78.82%).

Regarding the total fixed cost incurred in paddy cultivation under natural farming, land revenue (Rs.65) and depreciation charges (Rs. 1,289.50) are of minor importance. The rental value of land (Rs.6240) was the major item accounting for 15.54 per cent and interest on fixed capital accounted for about two per cent in the total cost of cultivation. The total fixed cost was Rs. 8,505.84 sharing 21.18 per cent in the total cost of cultivation.

The total cost of cultivation for paddy per acre under natural farming was Rs. 40,164.98 and the farmers spent Rs.911.34 to produce a quintal of paddy. The total marketing cost incurred by farmers to sell produce grown in one acre was Rs. 2,100.20, which included charges of Rs.380 as cost of packaging bags, Rs.638.90 towards packaging and transportation charges and Rs. 1,081.30 as commission charges.

3.1.2 Returns from paddy grown under natural farming

The details on yield and returns from paddy cultivated under natural farming per acre are detailed in Table 3. From the table, the paddy grain yield realised was 19.66 quintals per acre, and was sold at a rate of Rs. 2,340 per quintal and earned a total revenue of Rs. 46,004.40. Additionally, straw (2.15 tractor loads/ac) produced on farm used as fodder for livestock was valued at Rs. 4,245.65 per tractor load and contributing Rs. 9,128.15 to the total income. There was also supplementary income derived from trap crops, amounting to Rs. 1,256.78. Consequently, the gross returns per acre were found to be Rs. 56,389.33. After accounting for all expenses, the net returns realised were Rs. 16,224.35 and resulted in 1.40 as net income per rupee of expenditure.

Table 3: Yield and returns of paddy grown under natural farming

(Per ac)

Sl. No.	Particulars	Quantity	Rate (Rs.)	Value (Rs.)
1	Main products (q)	19.66	2,340.00	46,004.40

2	By products – Straw (tractor loads)	2.15	4,245.65	9,128.15
3	Income from trap crops			1,256.78
4	Gross returns			56,389.33
5	Net returns			16,224.35
6	Returns per rupee of investment			1.40

3.1.3 Economics of paddy grown under conventional farming

The details on item-wise cost of cultivation of paddy grown under conventional farming are presented in Table 4. It could be observed from the results presented in table that for cultivation of one acre of paddy under conventional farming farmers spent a total cost of Rs. 47,503.89 which consisted of Rs. 38,780.40 total variable cost (81.64%) and Rs. 8,723.49 total fixed cost (18.36%).

The variable cost, comprised of labour costs and material costs. In the total labour cost of Rs. 22,453.48 (47.27%), Rs. 16,425 was human labour cost (34.58%), of which Rs. 6,735 was spent on women labour and Rs. 9,690 was spent towards men labour. Farmer are now days using more of machine labour than bullock labour and spent only Rs.170.21 on bullock labour while machine labour cost was Rs. 5,858.27 and accounted for 12.33 per cent of the total cost of cultivation.

Regarding the material cost in paddy cultivation under conventional farming, farmers spent Rs.905.96 on seeds of main crop (1.91%), Rs. 3,223.33 on FYM (6.79%), Rs. 3,072.50 on fertilizers (6.47%), Rs. 3,140 on plant protection chemicals (6.61%), Rs. 1,728.57 on weedicides (3.64%) and Rs. 2,945.15 on irrigation (6.20%) and the total material costs amounted to Rs. 15,015.51 (31.61%). Furthermore, the total variable cost was Rs. 38,780.40 (81.64%) comprising of an interest component of Rs. 1,311.41 (2.76%) for working capital used in paddy cultivation.

With respect to the total fixed cost spent on paddy cultivation under conventional farming, major item was rental value of land (Rs. 6,587.56 and 13.87%) followed by depreciation charges (Rs. 1,136.27 and 2.39%), while land revenue (0.14%), and interest on fixed capital (1.97%) were of minor importance in the total of Rs. 8,723.49 (18.36%).

The per acre total cost incurred in the cultivation of paddy under conventional farming was Rs. 47,503.89 and resulted in production cost of Rs. 1,898.64 per quintal as farmers realised a yield of 25 quintals per acre. In addition, the total marketing cost per acre was Rs. 2,464.99 which included Rs.495 for bags, Rs.593.89 for packaging and transportation and Rs. 1,376.10 as commission charges.

Table 4: Cost of cultivation of paddy grown under conventional farming

(Per ac)

Sl. No.	Particulars	Quantity	Cost (Rs.)	Per cent
I	**Variable cost**			
A.	**Labour**			

1	Human Labour	49.10	16,425.00	34.58
	a. Women labour (days)	24.15	6,735.00	14.18
	b. Men labour (days)	24.95	9,690.00	20.40
2	Bullock Labour (Pair days)	0.18	170.21	0.36
3	Machine Labour (hours)	5.12	5,858.27	12.33
	Total labour cost		**22,453.48**	**47.27**
B.	**Material Costs**			
1	Seeds (kg)	22.88	905.96	1.91
2	FYM(t)	4.33	3,223.33	6.79
3	Fertilizers (kg)	191.44	3,072.50	6.47
4	Plant protection chemicals(l)	0.28	3,140.00	6.61
5	Weedicides(l)	0.19	1,728.57	3.64
6	Irrigation costs (acre inches)		2,945.15	6.20
	Total material cost		**15,015.51**	**31.61**
	Total working capital		37,468.99	78.88
	Interest on working capital @ 7 %		1,311.41	2.76
	Total variable cost		**38,780.40**	**81.64**
II	**Fixed cost**			
1	Land revenue		65.00	0.14
2	Depreciation		1,136.27	2.39
3	Rental value of land		6,587.56	13.87
4	Interest on fixed capital @ 12 %		934.66	1.97
	Total fixed cost		**8,723.49**	**18.36**
III	**Total cost of cultivation (Rs/ac)**		**47,503.89**	**100.00**
IV	**Cost of production (Rs/q)**		**1,898.64**	
V	**Marketing cost (Rs/ac)**		**2,464.99**	
	a. Bags (no.s)	33.00	495.00	
	b. Packaging and transportation		593.89	
	c. Commission charges		1,376.10	

3.1.4 Returns from paddy grown under conventional farming

The per acre yield and economic returns from paddy cultivation under conventional farming were analyzed and results are presented in Table 5. The results revealed that the grain yield obtained was 25.02 quintals which realised total revenue of Rs. 51,958.20 when sold at Rs. 2,076.67 per quintal. Additionally, by-product (straw) of 1.92 tractor loads was obtained per acre and valued at prevailing rate

of Rs. 4,310.54 per load adding Rs. 8,276.24 to the income. Thus, the gross returns and net returns realised were Rs. 60,234.44 and Rs. 12,730.54, respectively with resultant 1.27 returns per rupee of expenditure.

Table 5: Yield and returns of paddy grown under conventional farming

(Per ac)

Sl. No.	Particulars	Quantity	Rate (Rs.)	Value (Rs.)
1	Main products (q)	25.02	2,076.67	51,958.20
2	By products – Straw (tractor loads)	1.92	4,310.54	8,276.24
3	Gross returns (Rs.)			60,234.44
4	Net returns (Rs.)			12,730.54
5	Returns per rupee of expenditure			1.27

3.2 Comparative economics of paddy grown under natural and conventional farming

The comparative analysis of paddy grown under natural and conventional farming was done and the results are presented in Table 6. It could be observed from the table that the cost of cultivation per acre of paddy was found to be more than 15 per cent higher in conventional farming (Rs. 47,503.89) than natural farming (Rs. 40,164.98); which was majorly due to the differences in material cost. Similar results were found by Kumar *et al.* (2019) and Prasad *et al*. (2024). However, the operational costs such as costs incurred on human labour were found to be higher in case of naturally grown paddy, these results were to be in accordance with Kumar *et al.* (2023). The cost of production per quintal of paddy was lower in conventional farming (Rs. 1,898.64) than natural farming (Rs. 2,042.98), which was due to 21 per cent higher output realised under conventional farming.

The income from main product was higher in conventional farming (Rs. 51,958.20) than natural farming (Rs. 46,004.40); whereas, the income from by product was higher in natural farming (Rs. 9,128.15) than conventional farming (Rs. 8,276.24). Similarly, the gross returns from conventional farming (Rs. 60,234.44) were about six per cent higher than natural farming (Rs. 56,398.33) but, the net returns from natural farming (Rs. 16,224.35) were 27 per cent higher than conventional farming (Rs. 12,730.54). Eventually, the returns per rupee of expenditure was also found to be ten per cent higher in natural farming (1.40) than conventional farming (1.27) exclusively attributable due to reduced costs in natural farming in spite of underproduction, similar results were reported by Jayaraj and Periyasamy (2023).

Table 6: Comparative costs and returns of paddy grown under natural and conventional farming

(*Per acre)*

	Particulars	FPNF	FPCF	Difference

Sl. No.		Value (Rs.)	Value (Rs.)	Value	Per cent
1	Variable costs				
i.	Labour costs				
	a. Human labour cost	18,073.33	16,425.00	1,648.33	10.04
	b. Bullock labour cost	181.23	170.21	11.02	6.47
	c. Machine labour cost	5,160.47	5,858.27	-697.80	-11.91
	Total labour cost	23,415.03	22,453.48	961.55	4.28
ii.	Material cost	7,173.51	15,015.51	-7,842.01	-52.23
	Total variable costs	31,659.13	38,780.40	-7,121.27	-18.36
2	Fixed costs	8,505.84	8,723.49	-217.64	-2.49
3	Cost of cultivation (Rs/acre)	40,164.98	47,503.89	-7,338.91	-15.45
4	Cost of production (Rs/q)	2,042.98	1,898.64	144.34	7.60
5	Main products - yield(q/acre)	19.66	25.02	-5.36	-21.42
6	Price (Rs/q)	2,340.00	2,076.67	263.33	12.68
7	Income from main products	46,004.40	51,958.20	-5,953.80	-11.46
8	Income from by products	9,128.15	8,276.24	851.91	10.29
9	Gross returns	56,389.33	60,234.44	-3,845.11	-6.38
10	Net returns	16,224.35	12,730.54	3,493.80	27.44
11	Returns per rupee of expenditure	1.40	1.27	0.14	10.72

Note: FPNF - Farmers Practicing Natural Farming and FPCF - Farmers Practicing Conventional Farming

The cost of paddy cultivation was found to be lower under natural farming due to reduced reliance on external chemical inputs such as fertilizers and pesticides. Instead, natural farmers utilized on-farm inputs like jeevamrutha, which significantly, lowered the overall cultivation costs similar results were reported by Prasad *et al.* (2024).The lower input costs associated with natural farming, resulted in higher net returns for paddy cultivated using natural farming practices compared to paddy grown under conventional farming, similar results were found by Shyam *et al.* (2019) and Koner and Laha (2020). The yield under natural farming was lower compared to conventional farming due to usage of

inputs like jeevamrutha and other natural inputs, these results are contradictory to Amareshwari and Sujathamma (2014) who reported higher yields by usage of natural inputs

3.3 Decomposition analysis of difference in net returns of paddy grown under natural and conventional farming

The production function estimates with net returns as dependent variable and factors contributing to the differences in net returns between paddy cultivated under natural and conventional farming systems were analyzed, and the findings are presented in the following sections.

3.3.1 Production function estimates and structural break in production relations of paddy grown under natural and conventional Farming

The production function estimates for paddy cultivated under natural and conventional farming conditions with net returns as dependent variable were estimated using OLS method are presented in Table 7.

Table 7: Production function estimates of paddy grown under natural and conventional farming

Sl. No.	Particulars	Parameter	FPNF	FPCF	Pooled
1	No. of observations	N	30	30	60
2	Intercept	ln A	5.9362 (0.24)	6.3443 (0.17)	5.8941 (0.12)
3	Seeds (kg)	X_1	0.2330*** (0.08)	0.1204* (0.07)	0.2311*** (0.06)
4	Gana Jeevamrutham/ FYM (q)	X_2	0.0914* (0.05)	0.2008*** (0.05)	0.1289*** (0.04)
5	Dhrava Jeevamrutham/ Fertilizers (l/kg)	X_3	0.1633*** (0.05)	0.1815*** (0.05)	0.1666*** (0.04)
6	Human labour (md)	X_4	0.4451*** (0.08)	0.1083 (0.07)	0.3324*** (0.06)
7	Machine labour(hrs)	X_5	0.0767 (0.06)	0.3933*** (0.07)	0.1479*** (0.04)
8	Dummy for method of farming	D			0.3071*** (0.11)
9	Returns to scale		1.01	1.00	1.31
10	Coefficient of Multiple determination	R^2	0.86	0.90	0.88

Note: ***, ** and * indicates significant at one per cent, five per cent and 10 per cent level of probability, respectively and figures in parentheses indicate standard errors

FPNF- Farmers Practicing Natural Farming and FPCF-Farmers Practicing Conventional Farming

It can be observed from the Table 7 that in case of paddy grown under natural farming, variables such as seeds (0.2330), dhrava jeevamrutha (0.1633) and human labour (0.4451) were found to be significantly influencing the net returns and coefficients were significant at one per cent probability level. Gana jeevamrutham coefficient (0.0914) was significant at ten per cent probability level. Almost constant returns to scale (1.01) were prevailing in paddy production and the model was found to be good fit to the data as indicated by high R^2 value (0.86). In other words, 86 per cent of the variation in net returns was explained by the explanatory variables included in the model.

In case of paddy grown under conventional farming, independent variables such as FYM (0.2008), fertilizers (0.1815) and machine labour (0.3933) were found to most significantly influence variables of net returns and their coefficient were significant at one per cent probability level. While, seed coefficient (0.1204) was significant at ten per cent probability level. As in the case of natural farming practicing farmers, conventional farming practicing farmers were also experiencing constant returns to scale (1.00) and the R^2 (0.90) value indicated that 90 per cent of the variation in net returns was explained by the explanatory variables included in the model.

Further, it could be observed from the results presented in last of column of the Table 7 that for the pooled production function the dummy variable coefficient was significant at one per cent probability level and offered the required justification to go for isolating different sources contributing for difference in net returns between the two farming situations using Decomposition model.

3.3.2 Sources contributing to difference in net returns between paddy grown under natural farming and conventional farming

The information presented in Table 8 provides details on sources contributing to the difference in net returns in paddy between farms practicing natural farming and conventional farming practices. The total observed difference in net returns was 25.98 per cent, reflecting the overall benefit of adopting natural farming practices over conventional farming. The breakdown of sources of increase in net returns consists of two major components i.e., the technology component and the input contribution**.**

The technology component, accounted for 20.25 per cent of increase in net returns, which represents the impact of technological advancements or changes on production relations. This component consisted of neutral and non-neutral effects. The neutral component, with a contribution of -40.81 per cent, indicates a negative impact and in contrast, the non-neutral component has a significant positive contribution of 61.06 per cent, highlighting that technological (shifting to natural farming) changes contributed to the observed increase in net returns.

To the increased net returns under natural farming, inputs contributed to the extent of 5.73 per cent with varied contributions from different inputs. Seeds provided a positive contribution of 2.23 per cent, indicating favoured contribution under natural farming over conventional farming. Gana jeevamrutham had a negative impact of -23.46 per cent, showing that the use of this input led to lower productivity in natural farming, this reveals that even with reduced usage of this input the present level of net returns would be increased to higher level. Conversely, dhrava jeevamrutham contributed positively at 24.68 per cent, highlighting effect of this input in boosting the productivity and higher net

returns. Human labour contribution was 2.87 per cent to the difference in net returns. On the other hand, machine labour had a very little and negative contribution (-0.59%) to the difference in net returns, suggesting that mechanized labour usage under natural farming slightly reduced the difference in net returns, Similar observations were made by Basavaraja *et al.* (2008) with respect to the effect of technology on economic advantages.

Table 8: Sources contributing to difference in net returns between paddy grown under natural farming and conventional farming

Sl. No.	Particulars	Per cent
I	**Total difference in net returns**	**25.98**
II	**Sources of output growth**	
1	**Technology component**	**20.25**
a	Neutral component	-40.81
b	Non-neutral component	61.06
2	**Input contribution**	**5.73**
a	Seeds (kg)	2.23
b	Gana Jeevamrutham/FYM (q)	-23.46
c	Dhrava Jeevamrutham/Fertilizers (l/kg)	24.68
d	Human Labour (md)	2.87
e	Machine labour(hrs)	-0.59
III	**Total estimated difference in net returns**	**25.98**

The total estimated difference in net returns consisted of the combined contributions of technology and difference usage of inputs between the two situations, aligned with the overall observed difference of 25.98 per cent.

4. CONCLUSION

The cost of cultivation per acre of paddy was found to be 15 per cent higher in conventional farming (Rs. 47,503.89) than natural farming (Rs. 40,164.98); which was majorly due to the difference in material costs which was attributed by reduced reliance on external chemical inputs such as fertilizers and pesticides. Instead, natural farmers utilized on-farm inputs like jeevamrutha, which significantly, lowered the overall cultivation costs. This approach ultimately led to the potential for higher net returns while keeping production costs low. However, the operational costs such as costs incurred on human labour were found to be higher in case of naturally grown paddy and also the yields were lower under natural farming compared to conventional farming. The gross returns from conventional farming (Rs. 60,234.44) were about six per cent higher than natural farming (Rs. 56,398.33) but, the net returns from natural farming (Rs. 16,224.35) were 27 per cent higher than conventional farming (Rs, 12,730.54). The

returns per rupee of expenditure was also found to be ten per cent higher in natural farming (1.40) than conventional farming (1.27) exclusively attributable due to reduced costs in natural farming in spite of underproduction.

The total observed difference in net returns was 25.98 per cent, reflecting the overall benefit of adopting natural farming practices over conventional farming. The breakdown of sources of increase in net returns consisted of two major components i.e., the technology component and the input contribution**.** The technology component, accounted for 20.25 per cent of increase in net returns, which represents the impact of technological advancements or changes on production relations and the inputs contributed to the extent of 5.73 per cent with varied contributions from different inputs.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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