

**THE EFFICIENCY OF DRIP IRRIGATION VS FLOOD IRRIGATION IN COCONUT  
PRODUCTION – AN AGRO-ECONOMIC STUDY IN  
TIRUPPUR DISTRICT OF TAMIL NADU**

**ABSTRACT**

Coconut also called as Kalpavriksha, which means tree of heaven, because of its usefulness from each part of the tree. India is one of the leading producers of coconut in the world as India stands third place in terms of area under coconut cultivation followed by Indonesia and Philippines. Though coconut has several uses, it requires high amount of water for growth and it is about 800 to 1000 mm annually. The study was aimed to find the irrigation method, which would be efficient for coconut cultivation. Hence, to compare the yield, profitability and efficiency of coconut production among drip irrigated and flood irrigated farms, a study was formulated in Tiruppur district with a sample of 40 drip irrigated and 40 flood irrigated farms constituting a total of 80 coconut farms. The study found that net returns was also comparatively low in flood irrigated farm category Rs. 88962.76, as against the net return of Rs. 112374.14 in drip irrigated farm category. The results of benefit cost ratio was higher in drip irrigated farm category (1.51) as compared to drip irrigated farm category (1.42). This might be mainly due to the increased yield obtained in drip irrigated farms than flood irrigated farms due to better efficiency of production. The mean technical efficiency was found to be 76.58 percent and 87.66 percent in flood irrigated and drip irrigated coconut farms respectively. It can be concluded from the analyzed results that the coconut production, profitability and efficiency is high in drip irrigated farms and hence the study recommends for adoption of drip irrigation for coconut cultivation, leading to sustainable water use as by the sixth sustainable development goal.

**Keywords:** Coconut production; efficiency; drip irrigation; flood irrigation.

**Comment [S1]:** \*\*Clarify: in which language it is called Kalpavriksha at Introduction section

**Comment [S2]:** \*\*Correction: Flood irrigated

## INTRODUCTION

India is one of the leading producers of coconut in the world as India stands third place in terms of area under coconut cultivation followed by Indonesia and Philippines. Also, India occupies first place and second place in terms of production and productivity (Muthumani and Sathuragiri, 2022). Coconut is a perennial crop and its life span ranges from 50 to 60 years from planting and gives yield till lifespan if provided with proper management and care (Vanitha and Janagam, 2019). It can be harvested 4 - 10 times per year and it depends upon the yield, variety and purpose. The yield also varies for each harvest and year from planting.

Considering the importance of coconut, it is rightly called as Kalpavriksha, which means tree of heaven, because of its usefulness from each part of the tree (Naveena et al., 2014). It is also called as Tree of Abundance, Tree of life, etc., (Shanthini and Ramane 2018).

Coconut has several medicinal properties and the entire crop products has several uses. On considering its usefulness and in order to promote the same, Coconut development board was established by the Government of India under the ministry of agriculture and farmers welfare. More than 12 million people in the country depends upon coconut cultivation, marketing and other related activities (Preethi et al., 2018). Having so much importance, like others the coconut also has a disadvantage of high-water requirement of about 800 to 1000 mm annually. This is because of being perennial in nature and the nut itself contains water in its endosperm. As the country India, itself is a water stressed nation (Jain 2011), irrigating coconut crop through flooding requires a lot of water and also expensive during cultivation practices. On the other side, considering the evapotranspiration, a huge volume of irrigation water is lost during evapotranspiration.

Evapotranspiration is the sum of evaporation and transpiration. Loss of water from the surface of the land due to stagnation of water and sunshine as water vapor is called evaporation, whereas loss of water from plants through the stomatal opening as water vapor is called transpiration. In 1940, an Israel engineer Symcha Blasé found that a tree closer to a leaking faucet exhibited vigorous growth than other trees. This became the concept of drip irrigation in the later years.

In flood irrigation, water loss happens through transpiration and evaporation, whereas in drip irrigation, water loss through evaporation is highly minimized or almost equal to zero. Several literatures stated that drip irrigation saved water up to 50 percent. The core aim of the study is to find an efficient method of irrigation, and hence a study was formulated to compare the benefits of drip irrigation over flood irrigation with the following objectives.

### **Objectives**

- To calculate and compare the cost and returns of coconut production in drip irrigated farms and flood irrigated farms of the study area
- To compare the efficiency of coconut production between drip irrigated farms and flood irrigated farms of the study area

**Comment [S3]:** \*\*Summarize: writing the research objectives in a paragraph will be more scientific while writing a research paper. Also, mention why this is important to scientific community.

### **Material and Method**

#### **Area selection and sampling**

Tiruppur is one of the leading districts in Tamil Nadu in area under coconut cultivation (Kannan et al., 2017). Area under coconut cultivation is about 63011.99 ha in Tiruppur district alone, which is about more than 50 percent of the district's irrigated area and hence Tiruppur district is purposively selected for this study based on the suitability to objectives. In Tiruppur district, two blocks namely Udumalapettai and Gudimangalam were selected, as both the blocks have majority of coconut plantation in Tiruppur district.

Multistage purposive and random sampling was followed. 40 drip irrigated coconut farms and 40 flood irrigated farms were selected randomly in both the blocks and a total of 80 coconut growers in the Tiruppur district was selected and primary data was collected from well-structured questionnaire related to coconut cultivation aspects.

### **Tools of analysis**

#### **Cost and returns**

Farmers planted coconut in different time periods and their investments differ. To bring these costs on par, the investments and all the costs incurred were considered for the year 2023 and calculated. The average establishment costs over years were collected by data collection from coconut growers.

**Inputs cost:** The actual cost incurred for various inputs like manures, fertilizers, plant protection chemicals, labour, etc., were considered.

**Irrigation water cost:** Irrigation cost in the present study was calculated by volumetric pricing method. Equipment's related to irrigation like pumpset, borewell, conveyance and storage structures, etc., were identified and their lifespan was considered. Later, the capital investment made were compounded to the present year with 2 percent discount rate and amortized based on its lifespan, this gives the total cost of irrigation by amortization (Nagaraj and Anitha, 2022). Quantity of water pumped out and Number of irrigations per hectare per year for each crop was calculated. Finally, the total annual cost of irrigation by amortization divided by total volume of water pumped out gives the cost of irrigation per unit volume of water. Cost of irrigation per unit volume of water multiplied by volume of water irrigated per hectare per year for a crop gives cost of irrigation per hectare per year for each crop.

**Land:** To include the share of land in the total cost of production, the imputed rental value of owned land was considered.

**Interest on Working and Fixed Capital:** Interest on working capital was computed at the rate of seven percent per annum, the rate at which the commercial banks advance short-term loans to the farmers. Interest on fixed capital was worked out at the rate of 12 percent per annum, the rate charged for long term loans by the commercial banks.

**Land Revenue:** Land revenue actually paid by the farmers was considered.

Later on, all the above-mentioned variables were converted to a hectare for calculation.

### **Production function analysis**

Cobb-Douglas type of production function analysis was employed based on the literatures by Karthick et al., (2013) and Jeevan et al., (2018). The production function for coconut was

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} U_i \text{-----(1)}$$

where, Y – Coconut yield (in nuts/ ha)

X<sub>1</sub>, - Manures (in kg/ha),

X<sub>2</sub>, - Complex fertilizers (in kg/ha),

X<sub>3</sub>, - Potassic fertilizers (in kg/ha),

X<sub>4</sub> - Micronutrient mixture (in litre/ha) and

X<sub>5</sub> - Plant protection chemicals (in litre/ha)

X<sub>6</sub> - No. of irrigations (in No./ha),

β<sub>0</sub> - Constant, U<sub>i</sub> - Error term, β<sub>i</sub>'s - Parameters to be estimated.

### **Stochastic Frontier Production Function**

In order to assess the technical efficiency of coconut production, Stochastic frontier production function was employed. The model for cross-sectional data is  $Y = f(X_i, \alpha) e^{\varepsilon_i}$  (i = .....n) as defined by Aigner et al., (1977); Meeusen and Broeck (1977); Battese and Coelli (1988) where, Y<sub>i</sub> = Output of the i<sup>th</sup> farmer, X<sub>i</sub> = input quantities used of i<sup>th</sup> farmer, α = parameters to be estimated, ε<sub>i</sub> = A stochastic error-term consisting of two independent

components  $U_i$  and  $V_i$ , and  $\varepsilon_i = V_i - U_i$ . (Kittilertpaisan et al., 2016; Harshani and Shantha, 2021)

Variables like weather, occurrence of pest and diseases and other random variables are captured by the systematic, independent component  $V_i$ , which is equal to  $V_i \approx N(0, \sigma_v^2)$ . Another component  $U_i$ , accounts for the variation due to inefficiency from the frontier. This component is non-negative and follows normal distribution or exponential distribution (Giroh and Nachandiya, 2022). The variance of  $\varepsilon$  is given by  $\sigma^2 = \sigma_u^2 + \sigma_v^2$ , where, the term  $\sigma^2$  is the variance parameter that denotes the total deviation from the frontier,  $\sigma_u^2$  is the deviation from the frontier due to inefficiency, and  $\sigma_v^2$  is the deviation from the frontier due to stochastic noise.

Indicator of relative variability is represented by  $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ , which differentiates the actual yield from the frontier. When the value of  $\sigma_v^2$  is closer to zero, then the predominant error is  $U_i$ , it implies  $\gamma = 1$ . This means yield differences are mainly due to non-adoption of best practice or technique. Alternatively, when the value of  $\sigma_u^2$  tends to zero, then the symmetric error-term,  $V_i$  is the predominant error and leads  $\gamma$  to zero. This means the yield differences are mainly due to randomness or external factors that are not included in the model (Wakili, 2012; Karthick et al., 2015).

### The Model

The stochastic frontier production function used in the study was given by Equation (3):

$$\ln(Y) = \alpha_0 + \alpha_1 \ln(X_1) + \alpha_2 \ln(X_2) + \alpha_3 \ln(X_3) + \alpha_4 \ln(X_4) + \alpha_5 \ln(X_5) + \alpha_6 \ln(X_6) + \dots + \alpha_n \ln(X_n) + V_i - U_i \dots (3)$$

The mean technical efficiency is given by  $1 - \sigma_u(2/\pi)^{1/2}$  (Palanisami et al., 2002). The technical efficiency of individual farm was worked out by  $TE = Y_i/Y_i^*$  where,  $Y_i^*$  is the frontier yield and  $Y_i$  is the actual yield. (Bhende and Kalrajan, 2007; Giroh and Adebayo, 2009).

**Comment [S4]:** \*\*Re-write: Though, the content is sufficient, the author must write the section in a provided manuscript form. Author must write the sampling area, why you chose that area, the materials required and method in a sequence. No separate sub-heading is required.

## Results and Discussion

The results and discussion are as follows.

**Comment [S5]:** \*\*Statement: this is a very informal way to express your results. Try going to your findings directly.

UNDER PEER REVIEW

**Table – 1 Average cost of cultivation of coconut crop in Tiruppur district (1 to 7 years and above)**

S. No	Particulars	Iyear	IIyear	IIIyear	IVyear	Vyear	VIyear	VIIyear	>VIIyear
<b>A) Operational costs</b>									
1.	<b>Land preparation</b>	9528.45 (4.91)	2100 (1.20)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
2.	<b>Digging and pit filling</b>	4983.33 (2.57)	498.33 (0.28)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
3.	<b>Planting</b>	2000 (1.03)	200(0.11)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4.	<b>Other Labour charges</b>	18866.66 (9.72)	18867.66 (10.75)	24742.00 (11.99)	22308.33 (10.22)	22308.33 (11.23)	26308.33 (11.23)	22308.33 (11.23)	22308.33 (11.23)
	<b>Subtotal</b>	35378.44 (18.24)	21665.99 (12.35)	24742 (11.99)	22308.33 (10.22)	22308.33 (11.23)	22308.33 (11.23)	22308.33 (11.23)	22308.33 (11.23)
<b>B) Material costs</b>									
1.	<b>Manuring</b>	88000.36 (45.36)	88000.36 (50.15)	104529.66 (50.65)	104529.66 (47.86)	79147.55 (39.83)	79147.55 (39.83)	79147.55 (39.83)	79147.55 (39.83)
2.	<b>Seedling</b>	5000 (2.58)	500(0.28)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
3.	<b>Fertilizer</b>	16200.24 (8.35)	16200.24 (9.23)	26183.66 (12.69)	38186.33 (17.49)	45246.57 (22.77)	45246.57 (22.77)	45246.57 (22.77)	45246.57 (22.77)
4.	<b>Plant protection</b>	3050.33 (1.57)	3050.33 (1.74)	3050.33 (1.48)	4531.38 (2.07)	4483.5 (2.26)	4483.5 (2.26)	4483.5 (2.26)	4483.5 (2.26)
5.	<b>Irrigation</b>	15084.61 (7.78)	15084.61 (8.60)	15084.61 (7.31)	15084.61 (6.91)	15084.61 (7.59)	15084.61 (7.59)	15084.61 (7.59)	15084.61 (7.59)
6.	<b>Others</b>	2000 (1.03)	2000 (1.14)	2000 (0.97)	2000 (0.92)	2000 (1.01)	2000 (1.01)	2000 (1.01)	2000 (1.01)

**Comment [S6]:** \*\*Clarify: Mention cost unit, either USD Euros, or Indian Rupees. Try using USD or Euros as a unit of cost so that it will be easier for foreign researchers to look after. Make your currency unit consistency for all other costs.

7.	Interest on working capital @7%	9056.49 (4.67)	8738.49 (4.98)	10559.38 (5.12)	11503.24 (5.27)	10217.36 (5.14)	10217.36 (5.14)	10217.36 (5.14)	10217.36 (5.14)
	<b>Subtotal</b>	138389.03(71.33)	133574.03(76.12)	161407.64(78.20)	175835.22(80.52)	156179.58(78.59)	156179.58(78.59)	156179.58(78.59)	156179.58(78.59)
	<b>Total(A+B)</b>	173767.4(89.57)	155240.02(88.46)	186149.64(90.19)	198143.55(90.73)	178487.92(89.81)	178487.92(89.81)	178487.92(89.81)	178487.92(89.81)
<b>C) Fixed costs</b>									
1.	Rental value of land	15000 (7.73)	15000 (8.55)	15000 (7.27)	15000 (6.87)	15000 (7.55)	15000 (7.55)	15000 (7.55)	15000 (7.55)
2.	Land revenue	200 (0.10)	200 (0.11)	200 (0.09)	200 (0.09)	200 (0.10)	200 (0.10)	200 (0.10)	200 (0.10)
3.	Depreciation	2890.45 (1.49)	2890.45 (1.65)	2890.45 (1.40)	2890.45 (1.32)	2890.45 (1.45)	2890.45 (1.45)	2890.45 (1.45)	2890.45 (1.45)
4.	Interest on fixed capital	2152.85 (1.11)	2152.85 (1.23)	2152.85 (1.04)	2152.85 (0.99)	2152.85 (1.08)	2152.85 (1.08)	2152.85 (1.08)	2152.85 (1.08)
	<b>Subtotal</b>	20243.3 (10.43)	20243.3 (11.54)	20243.3 (9.81)	20243.3 (9.27)	20243.3 (10.19)	20243.3 (10.19)	20243.3 (10.19)	20243.3 (10.19)
	<b>Total cost (A+B+C)</b>	194010.7 7(100)	175483.32 (100)	206392.9 4(100)	218386.8 5(100)	198731.22 (100)	198731.22 (100)	198731.22 (100)	198731.22 (100)
<b>D) Returns</b>									
	Return from intercrop	30000	27000	0	0	0	0	0	0
	Return from coconut	0	0	0	0	187189.30	283967.52	319675.85	319675.85
	<b>Gross returns</b>	<b>30000</b>	<b>27000</b>	<b>0</b>	<b>0</b>	<b>187189.30</b>	<b>283967.52</b>	<b>319675.85</b>	<b>319675.85</b>
	<b>Net returns</b>	<b>-164010.7</b>	<b>-148483.32</b>	<b>-206392.9</b>	<b>-218386.8</b>	<b>-11541.92</b>	<b>85236.30</b>	<b>120944.63</b>	<b>120944.63</b>

The table - 1 shows the cost and returns of coconut production in its initial lifespan of the first 7 years and above. During this period, among the different cost components incurred in the cultivation of coconut, manure cost alone shares about 40 percent of the annual total cost in all the years. All the costs incurred for manuring, fertilizer application, plant protection, chemical spraying, harvesting, field maintenance, etc., were included in other labor charges and its share to the annual total cost is around 10 percent in all the years. The share of fertilizer cost to the total cost ranges from 8 to 16 percent and the share of irrigation accounts for about 7 percent individually in all the years. 10 percent of the total cost incurred for field preparation, planting, digging, and pit filling in the first year was taken as the cost for the second year.

The table also revealed that the share of field operational costs decreased from 18.24 percent in the first year to 11.23 percent in the seventh year. At the same time, the share of material cost was 71.33 percent in the first year and it increased to 78.59 percent in the seventh year. The reason is coconut crop requires more inputs for growth during its growth period than field operations. The share of fixed cost to the total cost is low and about 10 percent.

Among the samples, coconut started bearing from the fifth year with a gross income of Rs. 187189.30 and attained its maximum potential from the seventh or eighth year with a gross income of Rs. 319675.85. Hence, these 5 years can be stated as the establishment period, and from 6<sup>th</sup> year it can be stated as the bearing and maintenance period. The annual total cost for maintenance was found to be Rs. 194010.77, and it increased to Rs. 218386.85 in the fourth year and decreased to Rs. 198731.22, continuing to the end of its lifespan. This showed that there was an increasing trend of total annual costs in the establishment period and then remained the same in the maintenance period. If maintained properly, spraying timely plant protection chemicals,

and providing proper inputs, a hectare of coconut plantations will give net returns of Rs. 120944.63 from the seventh year to its lifetime.

During the period of establishment of coconut plantations, intercrops can be grown to acquire income and in this study area, banana is cultivated as an intercrop in the first two years of establishment period and it gives return of Rs. 30000 and Rs. 27000 in the first and second year respectively. The total net investment in the establishment period i.e., the sum of annual total cost incurred for establishment of coconut plantation up to five years was Rs. 993005.10 and total net returns up to fourteen years i.e., the sum of annual net returns from sixth year to fourteenth year was Rs. 1052793.34. It can also be stated that the amount spent during establishment period can be obtained in 14 years and the remaining years of bearing from the fourteenth year to lifespan stands for the profit. Hence, 14 years can be stated as pay-back period for establishment cost. The life span of coconut ranges from 40 to 70 years. Hence, the net returns obtained from coconut after fourteen years is completely profitable.

**Table – 2. Comparing the economics of coconut cultivation among drip irrigated and flood irrigated farms in Tiruppur district (in Rs./ha)**

S.No	Particulars	Flood irrigated Farms	Drip irrigated farms	Difference
1.	Manures	77193.55 (36.49)	80419.91 (36.89)	3226.36 (4.01)
2.	Fertilizers	42861.57 (20.26)	44100.32 (20.23)	1238.75 (2.81)
3.	Irrigation	13040.61 (6.16)	17983.33 (8.25)	4942.72 (27.48)
4.	Plant protection chemicals	4641.09 (2.19)	4123.43 (1.89)	-517.66 (-12.55)
5.	Labour	16308.88 (7.71)	13709.23 (6.29)	-2599.65 (-18.96)
6.	Interest on working capital	10783.20 (5.10)	11223.53 (5.15)	440.34 (3.92)
7.	Land revenue and depreciation	2941.45 (1.39)	3213.43 (1.47)	271.98 (8.46)
<b>I</b>	<b>Cost A1</b>	<b>167770.35 (79.31)</b>	<b>174773.18 (80.18)</b>	<b>7002.84 (4.01)</b>

<b>II</b>	<b>CostA2</b>	<b>167770.35</b> <b>(79.31)</b>	<b>174773.18</b> <b>(80.18)</b>	<b>7002.84</b> <b>(4.01)</b>
8.	Interest on Owned fixedcapitalasset	2112.57 (1.00)	2247.89 (1.03)	135.32 (6.02)
<b>III</b>	<b>CostB1</b>	<b>169882.92</b> <b>(80.31)</b>	<b>177021.07</b> <b>(81.09)</b>	<b>7138.16</b> <b>(4.03)</b>
9.	Rentalvalueofownedland	15000.00 (7.09)	15000.00 (6.88)	0 (0.00)
<b>IV</b>	<b>CostB2</b>	<b>184882.92</b> <b>(87.40)</b>	<b>192021.07</b> <b>(88.10)</b>	<b>7138.16</b> <b>(3.71)</b>
10.	Imputed value of familylabour	7412.45 (3.50)	6130.92 (2.81)	-1281.53 (-20.90)
<b>V</b>	<b>CostC1</b>	<b>177295.37</b> <b>(83.82)</b>	<b>183151.99</b> <b>(84.03)</b>	<b>5856.63</b> <b>(3.20)</b>
<b>VI</b>	<b>CostC2</b>	<b>192295.37</b> <b>(90.91)</b>	<b>198151.99</b> <b>(90.91)</b>	<b>5856.63</b> <b>(2.96)</b>
<b>VII</b>	<b>CostC3</b>	<b>211524.90</b> <b>(100.00)</b>	<b>217967.19</b> <b>(100.00)</b>	<b>6442.29</b> <b>(2.96)</b>
<b>VIII</b>	<b>Grossreturns</b>	<b>300487.67</b>	<b>330341.33</b>	<b>29853.67</b> <b>(9.04)</b>
<b>IX</b>	<b>Netreturns</b>	<b>88962.76</b>	<b>112374.14</b>	<b>23411.38</b> <b>(20.83)</b>

It was depicted from Table -2, that the total cost of cultivation of coconut per hectare per year in drip irrigated farm category was Rs. 217967.33, which was higher than the cost of cultivation of coconut in flood irrigated farm category (Rs. 211524.90) in Tiruppur district. This is due to investment made for drip irrigation structures, which increases the amortized cost of irrigation in case of drip irrigated farm category. Among the components of the cost A1, manures occupied the highest share in both the categories, with more than 36 percent each, followed by fertilizers, labour, etc. It should be noted that difference of cost between drip irrigated and flood irrigated farms in terms of fertilizers and plant protection chemicals are minor.

The cost incurred for fertilizers was higher in drip drip-irrigated farm category (Rs. 44100.32) than flood irrigated farm category (Rs. 42861.57). Similarly, irrigation cost was higher in drip irrigated farms (Rs. 17983.33) than flood irrigated farms (Rs. 13040.61). It was due to investments made for drip irrigation structures. Alternatively, labor charges (Rs. 13709.23) were lower in drip-irrigated farms

compared to flood-irrigated farms (Rs. 16308.88). This might be due to the fact that drip irrigation reduces weed growth, pest incidence, etc, which leads to reduced labor use. The table also showed that among the components of Cost A1, the lowest share in both categories was contributed by the land revenue (0.09 percent in both categories) and interest in working capital (about 5.1 percent in both categories).

The gross return was less in the flood-irrigated farm category than the drip-irrigated farm category, which accounted for Rs. 330341.33 and Rs. 300487.67, respectively. It could also be inferred from the table that the net returns were also comparatively low in flood irrigated farm category Rs. 88962.76, as against the net return of Rs. 112374.14 in the drip irrigated farm category. This might be mainly due to the increased yield obtained in drip irrigated farms than flood irrigated farms.

Further, it could be concluded from the table that when comparing the net returns from both categories, there was a significant difference in the net returns from the coconut crop, which was Rs. 23411.38. It was about 20.83 percent higher than net returns from flood-irrigated coconut farms. This proves the importance of improved irrigation technology (drip irrigation).

**Table – 3. Returns over cost for coconut cultivation in Tiruppur district (in Rs./ha)**

S.No	Particulars	Flood irrigated farms	Drip irrigated farms	Difference
1.	<b>Total costs</b>	211524.90	217967.19	6442.29 (2.96)
2.	<b>Gross income</b>	300487.67	330341.33	29853.66 (9.04)
3.	<b>Net income</b>	88962.76	112374.13	23411.38 (20.83)
4.	<b>Farm Business income</b>	132717.31	155568.14	22850.83 (14.69)
5.	<b>Farm investment income</b>	125304.86	149437.22	24132.36 (16.15)
6.	<b>Family labour income</b>	115604.74	138320.25	22715.51 (16.42)
7.	<b>Benefit cost ratio</b>	1.42	1.51	0.09

The table - 3, revealed that the gross income was less in flood irrigated farm category (Rs.300487.66) as compared to drip irrigated farm category (Rs. 330341.33). Also, the other measures of returns over different costs namely, farm business income, family labour income, net income and farm investment income were comparatively lower in flood irrigated farm category than drip irrigated farm category of coconut cultivation in Tiruppur district. It could also be observed from the results that the benefit cost ratio was higher in drip irrigated farm category (1.51) as compared to drip irrigated farm category (1.42). Thus, it could be inferred that in flood irrigated farm category, the efficiency of production was low, which may be due to the less yield obtained due to less efficiency of water use.

**Table – 4. Estimates of Cobb-Douglas production function of coconut in Tiruppur district**

S.No	Variables	Regression coefficients	
		Flood irrigated farms	Drip irrigated farms
1.	Intercept	6.232 <sup>***</sup> (1.579)	4.199 <sup>**</sup> (1.889)
2.	Manures (in Kg)	0.1979 <sup>*</sup> (0.1157)	0.1219 <sup>***</sup> (0.0372)
3.	Complex fertilizers (in Kg)	0.1051 <sup>*</sup> (0.0605)	0.2103 <sup>*</sup> (0.1106)
4.	Potassic fertilizers (in Kg)	0.2632 <sup>***</sup> (0.0967)	0.1903 <sup>***</sup> (0.0421)
5.	Micronutrient mixture (in L)	0.1728 <sup>*</sup> (0.0979)	0.3121 <sup>NS</sup> (0.1892)
6.	Plant protection Chemicals (in L)	0.3549 <sup>NS</sup> (0.3043)	-0.2337 <sup>NS</sup> (0.2137)
7.	Irrigation (in No.)	0.0407 <sup>NS</sup> (0.0601)	0.2488 <sup>**</sup> (0.1158)
8.	R <sup>2</sup>	0.5733	0.5361
9.	Adjusted R <sup>2</sup>	0.5516	0.5205
10.	N	40	40

Note-\*\*\*, \*\* and \* refer to significance at 1%, 5% and 10% levels respectively

The table – 4 showed the results of production function estimates

of coconut farms in Tiruppur district. The percentage of variation explained in flood irrigated coconut production was 57.33. Similarly, 53.61 percent variation in production of coconut from drip irrigated farms was explained by the selected explanatory variables. This could be revealed from the  $R^2$  values. The results also revealed that manures and complex fertilizers were positive and significant at 10 percent level. Potassic fertilizers and micronutrient mixture were significant at 1 and 10 percent level respectively. It means on increasing manures about one percent level from the geometric mean level, would increase the coconut production by 0.19 percent and one percent increase in complex fertilizers would increase the coconut production by 0.10 percent. Similarly, the elasticity of potassic fertilizers is about 0.26 and micronutrient mixture is about 0.17. The above-mentioned results are with respect to flood irrigated coconut farms in Tiruppur district.

Results with respect to drip-irrigated coconut farms were as follows. Manures and potassic fertilizers were positive and significant at 1 percent level. On increasing manures from geometric mean level to one percent, *ceteris paribus* would increase the coconut production by 0.12 percent and one percent increase in potassic fertilizers from the geometric mean level, *ceteris paribus*, would increase coconut production by 0.19 percent. Similarly, the variables complex fertilizers and irrigation were positive and significant at 10 and 5 percent levels respectively. The elasticity of complex fertilizers was 0.21, which revealed that 0.21 percent increase in coconut production can be made by increasing complex fertilizers up to one percent. The elasticity of irrigation is 0.24, indicating that 0.24 percent of output can be increased by increasing the irrigation by one percent, *ceteris paribus*. The variable plant protection chemicals was negative however, it is non-significant.

**Table – 5. Estimates of stochastic frontier production function of coconut farms in Tiruppur district**

S.No	Variables	Parameters	Coefficients	
			Flood irrigatedf arms	Dripirrigatedf arms
<b>I</b>	<b>Frontierproductionfunction</b>			
1	Intercept	$A_0$	1.91 <sup>***</sup> (0.0094)	1.2213 <sup>NS</sup> (0.823)
2	Manures(inKg)	$\alpha_1$	0.2142 <sup>***</sup> (0.0013)	0.2894 <sup>*</sup> (0.1534)
3	Complexfertilizers (inKg)	$\alpha_2$	0.09421 <sup>NS</sup> (0.0753)	0.2174 <sup>**</sup> (0.1023)
4	Potassicfertilizers( inKg)	$\alpha_3$	0.2529 <sup>NS</sup> (0.2932)	0.1738 <sup>NS</sup> (0.2134)
5	Micronutrient mixture(inL)	$\alpha_4$	0.1231 <sup>***</sup> (0.0342)	0.2032 <sup>*</sup> (0.0621)
6	Plant protectionchemic als(inL)	$\alpha_5$	0.1832 <sup>NS</sup> (0.121)	0.0732 <sup>NS</sup> (0.1421)
7	Irrigation(inNo.)	$\alpha_6$	0.2103 <sup>*</sup> (0.1177)	0.2642 <sup>**</sup> (0.1267)
<b>II</b>	<b>Diagnosticstatistics</b>			
1	Sigmasquare	$\sigma^2$	0.0981 <sup>**</sup> (0.0432)	0.067 <sup>**</sup> (0.0289)
2	Gamma	$\gamma$	0.8777 <sup>**</sup> (0.4162)	0.3567 <sup>**</sup> (0.1681)
3	Farmervariabili ty	$\sigma^2_u$	0.0861	0.0239
4	Randomvariability	$\sigma^2_v$	0.0120	0.0431
5	Loglikelihood		61.31	13.38
6	Meantechnicalef ficiency		76.58	87.66
7	No. ofobservation s	N	40	40

Note-\*\*\*, \*\*and\*referstosignificance at 1%, 5%and10%levelsrespectively

Technicalefficiencywasestimatedbyusingstochasticfrontierproduction and estimates of technical efficiency of coconut production in Tiruppur districtcouldbetracedfromtable-5.Thegammaestimate,whichisanindicatorof relative variability of  $U_i$  and  $V_i$  that differentiates the actual yield from the frontier;was significant at 5 percent level and the value of gamma was

0.8777 which means that 87.77 percent variation between observed, and frontier output was due to differences in the farmers practices or technology adopted in case of flood irrigated farms. The gamma value of drip irrigated farms was found to be 0.3567 which means 35.67 percent variation between observed and frontier output was due to random error.

The estimated  $\sigma^2_u$  and  $\sigma^2_v$  were 0.0861 and 0.0120, indicated that the difference in the yield was higher due to farmers practices rather than random variability in case of flood irrigated farms.

The estimated farmers variability (0.0239) was lesser than random variability (0.0431) for drip irrigated farms. The results also showed that except potassic fertilizers and plant protection chemicals all the variables were positive and significant and their production elasticities ranges from 0.12 to 0.29. The variable micronutrient mixture was significant at 1 percent level and 10 percent level in flood irrigated farms and drip irrigated farms respectively. One percent increase in micronutrient mixture level from geometric mean, *ceteris paribus* would increase the net production by 0.12 percent and 0.2 percent in flood irrigated and drip irrigated coconut farms respectively.

**Table – 6. Frequency distribution of technical efficiency of coconut farms in Tiruppur district**

S.No	Technical Efficiency class (%)	Flood irrigated farms		Drip irrigated farms	
		No. of farms	Percentage	No. of farms	Percentage
1	<50	0	0.00	0	0.00
2	51–60	4	10.00	0	0.00
3	61–70	10	25.00	2	5.00
4	71–80	9	22.50	12	30.00
5	81–90	9	22.50	11	27.50
6	>90	8	20.00	15	37.50
	Total	40	100.00	40	100.00
i)	Mean technical Efficiency (%)	76.58		87.66	

ii)	Maximum technical efficiency (%)	95.12	99.03
iii)	Minimum technical efficiency (%)	52.43	65.32

The table shows the frequency distribution of technical efficiency of Coconut farms in Tiruppur district. The mean technical efficiency was found to be 76.58 percent and 87.66 percent in flood irrigated and drip irrigated coconut farms respectively. In other words, maximum technical efficiency has not reached among the sample farms and 35 percent of the flood irrigated sample farms have less than 70 percent technical efficiency and in case of drip irrigated sample farms the technical efficiency is greater than 70 percent for majority of the farms. Maximum and minimum technical efficiency of flood irrigated coconut farms was 95.12 percent and 52.43 percent whereas in case of drip irrigated coconut farms it was 99.03 percent and 65.32 percent respectively.

### CONCLUSION

The study found that the gross return was less in the flood-irrigated farm category than in the drip irrigated farm category, which accounted for Rs. 330341.33 and Rs. 300487.67 respectively. It could be inferred that the net returns were also comparatively low in flood irrigated farm category Rs. 88962.76, as against the net return of Rs. 112374.14 in drip irrigated farm category. The results of benefit-cost ratio were higher in the drip irrigated farm category (1.51) as compared to flood irrigated farm category (1.42). This might be mainly due to the increased yield obtained in drip irrigated farms than flood irrigated farms due to better production efficiency.

Technical efficiency of coconut farms in Tiruppur district showed that the estimated farmers' variability was lesser than random variability for drip irrigated farms. Maximum

and minimum technical efficiency of flood irrigated coconut farms was 95.12 percent and 52.43 percent whereas in case of drip irrigated coconut farms it was 99.03 percent and 65.32 percent respectively. The mean technical efficiency was found to be 76.58 percent and 87.66 percent in flood irrigated and drip irrigated coconut farms respectively. This showed that 23.42 percent and 12.34 percent of technical efficiency can be increased in flood and drip irrigated coconut farms respectively. It can also be said that the efficiency of drip irrigation is very high compared to flood irrigation and also it is approaching closer to 100. It can be concluded that the coconut production, profitability and efficiency is high in drip irrigated farms and hence the study recommends for adoption of drip irrigation for coconut cultivation, leading to sustainable water use as the sixth sustainable development goal.

#### References

- Aigner, D., Lovell, C.K. and Schmidt, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of econometrics*, 6(1);21-37.
- Battese, G. and Coelli, T. 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Economics*, 28(4);387- 399.
- Bhende, M. J. and Kalirajan, K.P. 2007. Technical efficiency of major food and cash crops in Karnataka (India). *Indian Journal of Agricultural Economics*, 62(2);176-192.
- Giroh, D.Y. and Adebayo, E.F. 2009. Analysis of the technical inefficiency of rubber tapping in rubber research institute of Nigeria, Benin City, Nigeria. *Journal of Human Ecology*, 27(3);171-174.
- Giroh, D.Y. and Nachandiya, N. 2022. Technical efficiency and profitability of small holder naturalrubber production in southern Nigeria. *Journal of Plantation Crops*, 50(1);8-19.

- Harshani, K.A.P. and Shantha, A.A. 2021. Factors affecting the economic efficiency of small-scale rubber plantations: With special reference to Kalutara district in Sri Lanka. *Colombo Business Journal*, 12(1);145-165.
- Jain, S. K. 2011. Population rise and growing water scarcity in India - Revised estimates and required initiatives. *Current Science*, 101(3);271–276.
- Jeevan M.N., Mukhopadhyay, S., and Dey, G. (2018). Resource Use Efficiency of Subsistence and Commercial Crops—Comparative Economic Analysis of Ragi and Sunflower in Karnataka. *International Journal of Agriculture Sciences*, 10(22), 7528–7531.
- Karthick, V., Alagumani, T. and Amarnath, J.S. 2013. Resource–use efficiency and technical efficiency of turmeric production in Tamil Nadu—A Stochastic Frontier Approach. *Agricultural Economics Research Review*, 26(1);109-114.
- Karthick, V., Thilagavathi, M., Surendran, A., Paramasivam, R. and Balaji, S.J. 2015. Estimation of Resource Use Efficiency and Technical Efficiency of Small Onion Farmers in Tamil Nadu: A Cobb-Douglas and Stochastic Frontier Approach. *Eco Affairs*, 60(3);401.
- Kannan, B., Ragnath, K. P., Kumaraperumal, R., Jagadeeswaran, R. and Krishnan, R. 2017. Mapping of coconut growing areas in Tamil Nadu, India using remote sensing and GIS. *Journal of Applied and Natural Science*, 9(2), 771-773.
- Kittilertpaisan, J., Kittilertpaisan, K. and Khatiwat, P. 2016. Technical efficiency of rubber farmers' in Changwat Sakon Nakhon: Stochastic frontier analysis. *International Journal of Economics and Financial Issues*, 6(6S);138-141.
- Meeusen, W. and Broeck, V.D. 1977. Efficiency estimates from Cobb-Douglas production function with composed error. *International Economic Review*, 18(2);435-444.
- Muthumani, K. and Sathuragiri, V. 2022. A study on Coconut Cultivation practices and

satisfaction among the farmers in Theni district. *World Wide Journal of Multidisciplinary Research and Development*, 8(05);88-93.

Nagaraj, N. and Anitha, S. 2022. Impact of micro irrigation on groundwater savings, productivity, and profitability of principal crops in the Eastern Dry Zone and Central Dry Zone of Karnataka: a resource economic analysis. *Agricultural Economics Research Review*, 35(1);57-70.

Naveena, K., Santosha, R., Garima, S. and Yogish, K.J. 2014. Forecasting of coconut production in India: a suitable time series model. *International Journal of Agricultural Engineering*, 7(1);190-193.

Palanisami, K., Paramasivam, P. and Ranganathan, C.R. 2002. *Agricultural Production Economics: Analytical methods and Applications*, Associated Publishing Company, New Delhi.

Preethi, V.P., Thomas, K.J. and Kuruvila, A. 2018. Performance of coconut in India: A trend analysis. *Journal of Tropical Agriculture*, 56(2);210-214.

Shanthini, G. and Ramane, R.V. 2018. An analysis of growth trends of coconut crop in India. *International Journal of Research in Management Economics and Commerce*, 8(3);78-85

Vanitha, V. and Janagam, D. 2019. Concurrent Estimation of Coconut Construction in Krishnagiri and Dharmapuri Districts of Tamil Nadu. *Think India Journal*, 22(4); 10709-10719.

Wakili, A.M. 2012. Technical efficiency of maize farmers in Gombi local government of Adamawa State, Nigeria. *Agricultural Journal*, 7(1);1-4.

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