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Profitability and sensitivity analysis of oil palm cultivation in Telangana

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Abstract
This study analyse the profitability of oil palm cultivation in Telangana State specifically focusing on Badradri Kothagudem and Khammam districts which are leading with substantial oil palm plantations spanning over 26,590 ha and 12,405 ha respectively. Employing a multi-stage random sampling method, both primary and secondary data were gathered from selected mandals, villages and 120 oil palm growers to assess its economic viability. The study examined both the establishment and maintenance cost structures for oil palm cultivation distinguishing between variable and fixed costs. Key findings revealed that the gross income from oil palm orchards over a 25-year economic life period was Rs. 76.8 lakhs, with total costs amounting to ₹ 52 lakhs, resulting in a net income of ₹ 24.8 lakhs per ha.

The financial analysis indicated an internal rate of return (IRR) of 14.5%, a benefit-cost ratio (BCR) of 1.41, and a net present value (NPV) of ₹ 6,48,837 at a 5% discount rate, indicating positive returns. Sensitivity analysis showed that increases in total costs by 5% and 10% lowered the NPV and BCR, with IRR respectively. Similarly, an increase and decrease in yields by 5% affected profitability, bringing BCRs to 1.49 and 1.35 respectively, with the system remaining viable up to 30% reduction in returns beyond which it is unsustainable . The break-even point for oil palm production was determined at 208 MT with a total fixed cost of ₹ 18.1 lakhs, an average variable cost of ₹ 6881/MT, and an average selling price of ₹ 15564.75/MT.

These results underscore the economic potential of oil palm in Telangana despite fluctuations in costs and revenues, emphasizing its viability as a long-term investment. The study suggests that supporting policies, particularly in stabilizing input costs and facilitating price assurances, could enhance profitability further for oil palm farmers, making it as a promising crop for sustainable agricultural development in the region.

Keywords: Oil palm cultivation, profitability analysis, cost-benefit analysis, internal rate of return, sensitivity analysis

1. Introduction

Oil palm (*Elaeis guineensis Jacq.*), is the crop of the present and future vegetable oil economy of the world as well as India. Oil palm cultivation assumes significance for augmenting the indigenous availability of edible oil as it is the highest oil-yielding perennial crop with 4-5 MT of palm oil and 0.4-0.5 MT palm kernel oil (PKO) per ha among other edible oil crops giving regular and assured income to farmers up to 25 years. In comparative terms, the yield of palm oil is 5 times the yield of edible oil obtained from any traditional oilseeds.

1.1 World Oil Palm Scenario

The global palm oil production as of March 2024-25 stood at 79.53 million MT. The leading oil palm producers are Indonesia and Malaysia. Indonesia remains the dominant global producer with 46.5 MMT accounting for 58.5% of the world's total production. Malaysia is the second largest producer with 19.2 MMT oil palm production (around 24.1%). Thailand produces about 3.70 MMT showing an increase from the previous year. Colombia reached with 1.90 MMT maintaining a steady growth. Nigeria's production stood constant at 1.50 MMT per annum. All other countries together contributed about 6.73 MMT per year. Overall, there is a general upward trend in global palm oil production from 49.38 MMT in 2010-11 to 79.53 MMT by 2024-25 with an annual compound growth rate of 3.57%.

1.2 Oil Palm Scenario in India

In India, oil palm is cultivated in an area of 4.59 lakh ha with a production of 3.29 lakh MT. India is the world second largest consumer of palm oil. The domestic production can meet only 43% of the demand within the country. The country has to rely on imports to meet the gap between demand and supply. India imported around 4.37 million MT of edible oils during the Oil Year 2002-03 (Nov-Oct) which is increased to 9.02 million MT during 2023-24 forming about 56% of total edible oil imports.

1.3 Oil palm Scenario in Telangana

In Telangana, oil palm is cultivated in an area of 98,415 ha by Dec 2025. The total production of CPO was 53,706 MT in the year 2022-23 far below the state's demand of 3.66 lakh MT. The major oil palm-growing districts in Telangana are Badradri Kothagudem and Khammam districts which together accounted for 32.81% of the area. Nalgonda, Suryapet and Mahabubabad are other major growing districts in the state. Badradri Kothagudem ranks first in terms of both area and production of oil palm followed by Khammam, Nalgonda and Suryapet. Badradri Kothagudem also has the highest oil palm productivity followed by Khammam and Nalgonda. The state is also a leader in Oil Extraction Rate (OER), boasting a 16.32% share of India's total crude palm oil (CPO) production.

As demand for palm oil rises both domestically and globally, understanding the economic viability and profitability of oil palm cultivation in Telangana is essential for guiding policy decisions and farmers' investment choices. This study analyses the economic aspects of oil palm cultivation in Badradri Kothagudem and Khammam districts focusing on the costs, returns, and financial sustainability of the crop.

2. Literature Review

The literature on oil palm provides insights into the economic viability and profitability with key variations influenced by geographic, agronomic, and market factors.

Reddy *et al.* (2022) [14] conducted a detailed analysis of oil palm cultivation in Andhra Pradesh, India, focusing on economic viability and resource efficiency. They observed that high transportation costs and limited access to organic manure drove farmers toward inorganic fertilizers. Their findings revealed that resources like manure and annuities of drip systems were underutilized while labor and transportation costs were over-utilized. Despite these challenges, the study found oil palm cultivation financially viable for large land-owning farmers with benefit-cost ratios of 2.98 (variable costs) and 1.49 (total costs) at a discount rate of 7%, and an internal rate of return (IRR) of 26.01%, indicating a strong financial case for this crop in Andhra Pradesh.

Ahmed (2021) [2] assessed the profitability of oil palm cultivation in India focusing on its favourable returns compared to other crops. The analysis highlighted the crop's high net present value (NPV), a benefit-cost ratio of 1.51, and an IRR of 28.41%. This financial performance alongside a low break-even point and payback period underscored the oil palm profitability. However, Ahmed noted the need for responsible growth to ensure that expansion does not negatively impact the environment.

Edison (2020) [6] evaluated smallholder oil palm plantations in Indonesia's Muaro Jambi District using a project evaluation approach. The results showed a positive NPV of IDR 21.3 million and an IRR of 19.9% making the project financially sustainable. The benefit-cost ratio of 2.24 is highlights the crop's strong economic appeal for smallholders.

Solmon *et al.* (2017) studied the economics of oil palm in the West Godavari District of Andhra Pradesh. He used spreadsheet model to develop and calculate the Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR). A sensitivity analysis of NPV to the default discount rate (11.5%) was included. A positive NPV of Rs. 1,57,487, IRR at 41.77% and BCR of 1.63 showed that establishing an oil palm plantation was a profitable investment.

Srilatha (2017) [15] studied the economic aspects of oil palm production in Nellore district of Andhra Pradesh. According to the study, the net income was from intercrops during the pre-bearing phase. The sale of oil palm fresh fruit bunches starts in the third year contribute to the orchardist's gross income. The gross income throughout the plant's economic life was estimated at Rs.9,63,135 per ha. The maximum net present value at a 12 percent discount rate was Rs. 65,201 while at a 24 percent discount rate, it was Rs. 15,103. Even at a larger discount rate of 24 percent, the benefit-cost ratio was 1.16 and IRR was 39.2% indicating that oil palm cultivation is a worthwhile endeavor.

According to Uma *et al.* (2015), the oil palm cultivation is not commercially viable and profitable for farmers in Krishna District. The NPV is Rs. 44,935 at 9 percent and the BCR of 1.17 implies a meager return per unit cost due to high maintenance costs. The IRR of 11.25 is just above the current market interest rate, indicating a low rate of return. The financial indicators are more sensitive to a 10% reduction in the market price of Fresh Fruit Bunches than to the same proportionate increase in costs.

These studies collectively affirm that oil palm cultivation can be a profitable investment, especially when supported by effective management, adequate resource allocation, and favourable financial metrics like high IRR and benefit-cost ratios. However, challenges such as high input costs, resource overuse, environmental sustainability, and market volatility remain requiring careful management and policy support to ensure long-term viability.

3. Materials and Methods

B-Kothagudem and Khammam are the two major districts with the largest oil palm areas in Telangana i.e., 26,590 ha and 13,790 ha respectively. A multi-stage random sampling procedure was used to select samples across Khammam and Bhadradri-Kothagudem. Two mandals from each district were chosen based on the largest area under oil palm. From each mandal, two villages were selected, and a sample of 15 farmers was randomly chosen from each village, with data collected on their oil palm production activities. Data collection focused on the agricultural year 2023-2024 and included both primary data from farmers and secondary data from local horticulture departments.

3.1 Net present worth/Net present value

This is simply the present worth of the future cash flow stream. The NPV of the project was calculated and derived from the total discounted income and costs. The net present value of a system over a period of time was derived by using the formula, where, Benefit in each year (Bt), Costs in each

year (Ct), time period (t), the number of years (n), discount rate (d).

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+d)}$$

Where
Bt = Cash inflow
Ct = Cash outflow

3.2 Internal rate of return (IRR)
The internal rate of return (IRR) compares a number of benefits and costs. IRR is the value of the discount rate at which the present value of expected investment returns equal to the present value of investment expenditure. It is interest income expected from the investment plan. This break through discount rate is the value of cash outflows equal to the value of cash inflows.

$$IRR = r_a + \frac{NPV_a}{NPV_a - NPV_b}(r_a - r_b)$$

Where
r_a = Lower discount rate
r_a-r_b = Difference between two discount rates
NPV_a = Present worth of cashflows at the lower discount rate
NPV_a-NPV_b = Absolute difference between the present worths of the cash flow at the two discount rates

3.3 Benefit Cost Ratio (BCR)
Benefit Cost Ratio (BCR) compares the present worth of costs with the present worth of benefits. To compute the following formula is used, where, Benefit in each year (Bt), Costs in each year (Ct), time period (t), the number of years (n), discount rate (d)

$$\text{B/C Ratio} = \frac{\text{Total discounted benefit}}{\text{Total discounted cost}}$$

$$\text{B/C Ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{1+r}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$$

Where
Bt = Cash inflow
Ct = Cash outflow

3.4 Break-even point
Break-even point is the point at which the two curves, total cost curve and total revenue curve intersect each other which indicate the level of production at which the producer neither loss money nor makes a profit. It was calculated by using the following formulae

$$BEP = \frac{TFC}{ASP - AVC}$$

Where
TFC = Total Fixed Costs
ASP = Average Selling Price
AVC = Average variable costs

3.5 Sensitivity analysis
Sensitivity analysis allows us to assess the economic risks associated with oil palm cultivation by evaluating its financial robustness under varying market conditions. This analysis considers how financial indicators are influenced by changes in total costs, income, discount rate, and selling price. By altering these financial indicators under different hypothetical scenarios, we can determine how sensitive the financial outcomes are to these changes. We evaluate the system's sensitivity to variations in total costs, income, selling price, and discount rate. For the selected oil palm plantations, the sensitivity analysis is conducted for the following scenarios:

- Increasing cost of capital
- Project cost estimation due to different risks
- Uncertainties arising from variations in receivable prices
- Instabilities due to fluctuations in selling prices

The four specific cases analyzed are
1. Increasing cost of capital
2. Changes in total costs
3. Changes in total yields
4. Changes in selling price

4. Results and Discussion
4.1 Cost Structure and Net Returns
The cost structure for oil palm was analyzed in two phases: establishment and maintenance. Establishment costs covered land preparation, plant materials, fertilizers, and plant protection for the first three years. During this period, farmers incurred a total cost of ₹ 7,06,050 while only inter-crops provided revenue. The net income during these years was negative, with losses of ₹ 105,018, ₹ 27114,, and ₹ 45,629 in the first, second, and third years, respectively.
The fig 1 illustrates the expenditure distribution across various inputs in three categories: Pooled average, Badradri Kothagudem, and Khammam. Among all cost components, total labour cost emerges as the highest in all regions, with Badradri Kothagudem showing the maximum and Khammam the least. Manure and fertilizer costs follow with minor variations where manure cost is slightly higher in Badradri Kothagudem and Khammam compared to the pooled average. Fertilizer cost is notably higher in the pooled average. Pesticide, fencing, and electricity costs are minimal across all regions. Weedicide and depreciation costs remain modest but visible with slight increases in pooled and Khammam respectively. Significant expenditure is also observed in the rental value of leased-in land which is highest in Khammam closely followed by Badradri Kothagudem. The annual share of establishment is another moderate component, highest in Badradri Kothagudem. Overall, labour and land rental costs constitute the major portions of total oil palm cultivation expenditure over the 25-year period with Badradri Kothagudem generally incurring higher costs compared to Khammam.
During the initial three years, there is no yield from oil palm and farmers rely solely on intercrop income. From the fourth year onwards, yields begin gradually increasing and stabilizing by the 8th year. Badradri Kothagudem records the highest total yield at 515 tons/ha followed by Khammam (472.25 MT/ha). The pooled average is 493 tons/ha. The price per ton remains constant at ₹ 15,564 across all years and regions.

Gross returns steadily increase with rising yields peaking in the 8-25-year range. Net returns are negative during the initial years due to high establishment and maintenance costs, turning positive from the sixth or seventh year. Over the full period, net returns are highest in Badradri Kothagudem (₹ 26.37 lakhs/ha) closely followed by Khammam (₹ 23.05 lakhs/ha) and the pooled average (₹ 24.71 lakhs/ha) indicating long-term profitability despite initial losses.

Table 1.1: Total Costs and returns from oil palm orchard during its economic life period (25 years)

S. No	Particulars	Value(Rs) lakh/ha		
		Badradri Kothagudem	Khammam	Pooled
1	Costs	53.7	50.4	52
2	Gross returns	80.1	73.5	76.8
3	Net Income	26.4	23.0	24.7
4	Annual Income	1.0	0.92	0.98

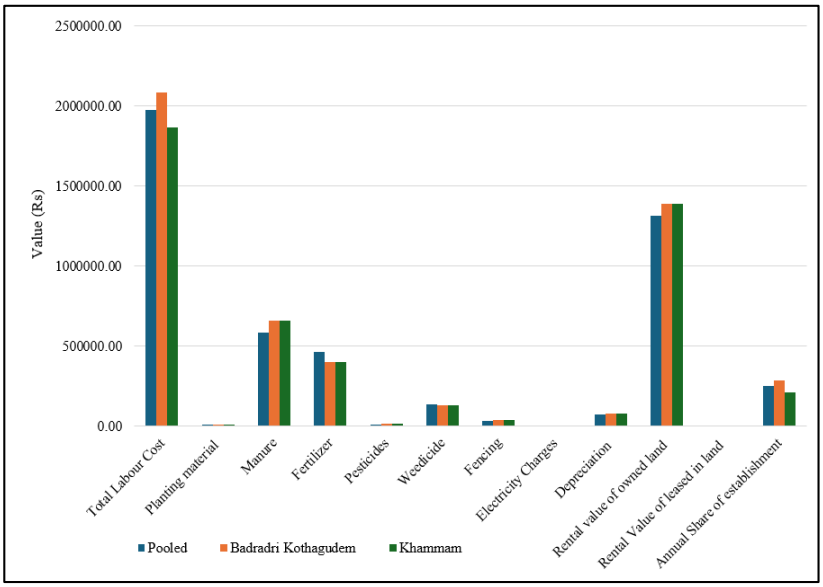

Fig 1: Cost Components of Oil Palm Cultivation Over a 25-Year Period (₹/ha)

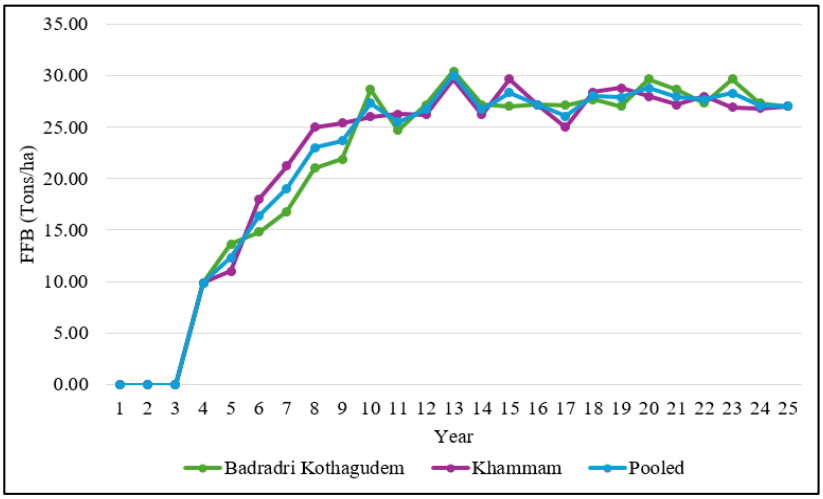

Fig 2: Yields from Oil Palm Plantation (1-25th Year)

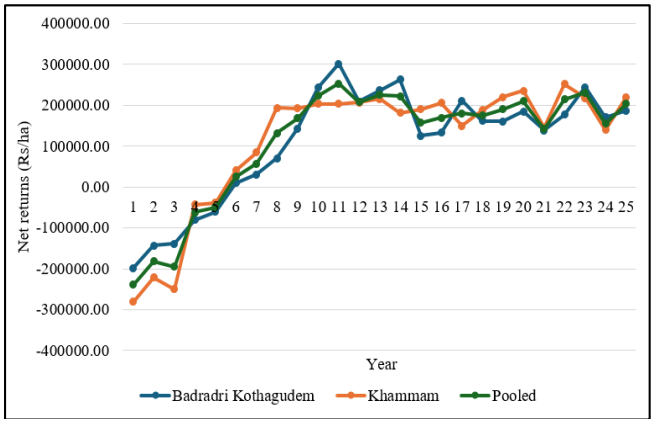

Fig 3: Net returns from Oil palm over its life time (1-25th year)

4.2 Economic Viability Indicators

Table 1.2 highlights that oil palm cultivation in the districts of Badradri Kothagudem and Khammam as well as the pooled average is found to be financially and economically feasible. The Net Present Value (NPV) across various discount rates (5%, 8% and 10%) remains positive in all cases indicating that the investment in oil palm cultivation yields returns that exceed the initial costs. Among the two districts, Khammam recorded the highest NPV values at all discount rates followed by Badradri Kothagudem suggesting a more profitable returns in Khammam.

The Benefit-Cost Ratio (BCR) which was recorded as 1.3 for Badradri Kothagudem, 1.5 for Khammam, and 1.45 for the pooled average, exceeded unity in all cases. This confirms that the benefits derived from oil palm cultivation

outweigh the costs involved, further reinforcing the economic soundness of the investment. Notably, Khammam once again outperforms with the highest BCR, highlighting its superior profitability potential. The break-even point is slightly lower in Khammam (202.13 MT) compared to Badradri Kothagudem (215.71 MT).

Table 1.2: Estimates of economic viability of oil palm orchards.

		Discount Rate		
Location	Indicator	5%	8%	10%
Badradri Kothagudem	NPV (Rs lakh/ha)	5.75	2.84	1.79
	BCR	1.3		
	IRR	14		
Khammam	NPV(Rs lakh/ha)	7.22	3.57	2.25
	BCR	1.5		
	IRR	15		
Pooled	NPV(Rs lakh/ha)	6.48	3.20	2.02
	BCR	1.4		
	IRR	14.5		

Table 1.3: Break Even Point

S. No	Particulars	Value (Rs.)		
		Badradri Kothagudem	Khammam	Pooled
1	Total Fixed Costs (Rs/ha)	19,03,014	17,24,868	18,13,941
2	Average Variable Costs (Rs/MT)	6742.67	7031.25	6880.76
3	Average Selling Price(Rs/MT)	15564.75	15564.75	15564.75
4	Break even point (MT)	215.71	202.13	208.88

In conclusion, while the pre-bearing period involves substantial costs and results in negative returns, the bearing period and the overall economic life span of oil palm orchards demonstrate strong profitability. The high NPV, favorable BCR, and substantial IRR underscores the economic viability and attractiveness of oil palm cultivation as a long-term investment.

Table 1.3 highlights that the total fixed costs are the highest in Badradri Kothagudem (Rs. 19,03,014) followed by the pooled average (Rs. 18,13,941) and the lowest in Khammam (Rs. 17,24,868). The average variable costs which include recurring expenditures like fertilizers, labor, irrigation, and maintenance, are fairly similar across all locations, with Khammam having the highest (Rs. 7031/MT) and Badradri the lowest (Rs. 6909/MT). The average selling price remains constant across districts at Rs. 15,564 per ton. As a result of the combination of higher fixed costs and similar selling prices, the break-even point is highest in Badradri Kothagudem, where a farmer needs to produce 216 tons to cover all costs. In contrast, Khammam has a lower break-even point of 202 tons meaning farmers there can achieve profitability at a lower production volume due to lower fixed costs. The pooled average break-even point stands at 208 tons representing the average performance across the regions.

Oil palm cultivation in Khammam is more economically favourable in terms of risk as farmers need to produce less to break even compared to those in Badradri Kothagudem. The lower break-even quantity in Khammam driven by lower fixed costs, indicates that farmers in this district reach profitability more quickly. Meanwhile, the higher break-even threshold in Badradri implies a greater initial investment burden and a longer time to profitability emphasizing the importance of yield optimization and cost management in that region.

4.3 Sensitivity Analysis

The four specific cases analyzed are:

4.3.1 Increase in cost of capital

Table 1.2 shows that NPV decreases with increasing discount rate. The NPV drops from Rs. 6.48 lakhs at 5% to Rs. 2.02 lakhs at 10% clearly showing that the oil palm cultivation becomes less attractive as the opportunity cost of capital increases.

4.3.2 Changes in total costs

In Table 1.5, the effect of a 5% and 10% increase in total costs is examined while keeping returns constant. With a 5% increase in costs, the discounted total cost rises to ₹ 19.15 lakhs yielding an NPV of ₹ 6.48 lakhs and a BCR of 1.34. Despite this cost hike, the project maintains a healthy margin of profitability. However, when costs increase by 10%, the NPV drops to ₹ 5.57 lakhs and the BCR to 1.28 with a notable decrease in IRR from 12% to 10%. This indicates a moderate sensitivity to cost inflation where the project still remains viable but experiences a gradual decline in returns.

4.3.3 Changes in total yields

A 5% increase in productivity enhances returns significantly resulting in a higher NPV of ₹ 8.96 lakhs and a BCR of 1.49. The IRR in this scenario is 16%. In contrast, a 5% reduction in yield brings down the NPV to ₹ 6.42 lakhs and BCR to 1.35. The IRR fell to 13%. These results indicate that yield improvements can substantially boost profitability whereas minor reductions can still keep the project economically feasible.

4.3.4 Changes in selling price

The analysis of price sensitivity revealed the strongest impact on profitability. At the average selling price (ASP) of

2024 ₹ 15,565/MT, the project generates an NPV of ₹ 6.4 lakhs and a BCR of 1.36, with an IRR of 12.8%. A 5% dip in the price to ₹ 14,787/MT reduces the NPV to 5.2 lakhs and BCR to 1.29. Further 10% fall in the price to ₹ 14,008/MT, the NPV fell to ₹ 5.15 lakhs, BCR of 1.28, and IRR of 10.8%. These figures underline that oil palm profitability is highly price-sensitive, and better market prices greatly enhance investment attractiveness.

Table 1.5: Change in NPV, BCR with increase in total costs @ 5% discount rate

S. No	Particulars	Discounted increased total costs	Discounted total returns	NPV	BCR	IRR
1.	Increase in Total costs by 5%	19,15,733	25,64,352	6,48,618	1.34	12%
2.	Increase in Total costs by 10%	20,06,958	25,64,352	5,57,393	1.28	10%

Table 1.6: Change in NPV, BCR with Change in productivity @ 5 discount rate

S. No	Particulars	Discounted total costs	Discounted reduced returns	NPV	BCR	IRR
1.	Increase in 5% yield	18,24,508	27,21,235	8,96,727	1.49	16
2.	Decrease in 5% yield	18,24,508	24,67,278	6,42,770	1.35	13

Table 1.7: Change in NPV, BCR with Change in average selling price @ 5% d rate

S. No	Particulars	ASP/MT	Discounted total costs	Discounted Total returns	NPV	BCR	IRR
1.	ASP 15565	15,565	18,24,508	24,73,325	6,48,816	1.36	12.8%
2.	5% decrease from 15565	14,787	18,24,508	23,52,393	5,27,885	1.29	11.0%
3.	10% decrease from 15565	14,008	18,24,508	23,40,300	5,15,792	1.28	10.8%

BCR of 1.60, and IRR of 18%. These figures underline that oil palm profitability is highly price-sensitive, and better market prices greatly enhance investment attractiveness.

Overall, the sensitivity analysis reinforces the importance of controlling costs, ensuring stable productivity, and securing favourable market prices. Among all factors, selling price variations exhibit the highest influence on economic returns followed by yield changes, while cost increases show moderate but manageable impact. This analysis underscores the need for efficient production practices and effective market linkages to maximize the economic potential of oil palm cultivation.

5. Policy Implications

To promote sustainable growth of oil palm in Telangana, targeted policy interventions are recommended. First, increased support for farmers during the initial establishment phase could be beneficial as high establishment costs and early losses present challenges. Subsidies on inputs like fertilizers, plant protection chemicals, and irrigation infrastructure can reduce financial burdens during the non-bearing period. Additionally, price stabilization mechanisms would protect farmers from market price fluctuations, improving financial security and encouraging long-term investment in oil palm.

6. Conclusion

Oil palm cultivation in Telangana demonstrates promising profitability, particularly in regions like Khammam and Bhadradri-Kothagudem with favourable agro-climatic conditions. Despite high initial costs and a delayed profitability phase, oil palm can yield substantial returns over its lifespan, as evidenced by high positive NPV, IRR, and BCR values. Sensitivity analysis suggests that profitability is moderately sensitive to cost increases and price declines, underscoring the need for support mechanisms. With targeted policy support, oil palm can be a lucrative addition to Telangana's agricultural landscape, offering substantial returns for farmers and supporting regional economic growth.

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