



# Evidence for the economic impacts of eucalyptus and subabul based agroforestry in Andhra Pradesh and Telangana

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**ABSTRACT:** Profitability, risk analysis and farmers perception were worked out for the Eucalyptus and Subabul based agroforestry growers in Telangana and Andhra Pradesh. A total of 465 farmers were considered under the survey in both states. Establishment cost of Subabul was considerably lesser but the maintenance cost was almost similar as compared to Eucalyptus. Gross returns of Subabul were better than Eucalyptus. Major constraints (as recorded in both states) in tree cultivation were: Price fluctuations > water problem > marketing > labour problem. This research helps the stakeholders such as farmers, researchers, government and non-government organizations and policymakers in decision making to promote agroforestry in India.

## Research Article

### ARTICLE INFO

Received: 24.04.2022

Accepted: 24.12.2022

### Keywords:

Agroforestry  
Profitability  
Risk analysis  
Farmer's perception  
Fast-growing trees

## 1. INTRODUCTION

The growing concern of global warming and climate change impacts on the global community have spurred interest in the sequestration of atmospheric carbon dioxide (CO<sub>2</sub>) in terrestrial ecosystem (Lal, R, 2015 & Sarkar et al., 2020). Sequestration is the process of removing atmospheric carbon (C) and depositing it in a reservoir/pool or transferring it into other long-lived pools (UNFCCC 2007).

“Agroforestry” has been identified as an effective strategy to store atmospheric CO<sub>2</sub> in the tree-based ecosystems (Nair et al., 2010) besides provisioning multi-benefits to the farmer. Agroforestry is a land-use system technology where woody perennials are deliberately grown on the same piece of land in the form of spatial arrangement or temporal sequence with agricultural crops and/or animals. Currently, in India, agroforestry is practiced between 17.45 m ha (Rizvi et al., 2014) to 23.365 m ha (Dhyani et al., 2013). The estimated area under agroforestry in India shows that Uttar Pradesh (1.86 m ha), Maharashtra (1.61 m ha) and Rajasthan (1.55 m ha) ranked first, second and third, respectively as per GIS data (Rizvi et al., 2014). Since ancient times, agroforestry is traditionally being practised in India for life and livelihood security. National Agroforestry Policy

2014 launched by the Ministry of Agriculture is promoting tree planting among the farmers in India. It meets almost half of the requirement of fuelwood consumption, 65%, 70–80%, 60%, and 9–11% for small timber, wood for plywood, raw material for paper pulp and green fodder requirement of livestock, respectively in addition to its environmental benefits (NRCAF 2013). Indian pulp and paper industry is producing currently about 14.99 million metric tons of paper and paperboard annually (CPPRI, 2015). About 315,000 hectares of land is covered under pulpwood production from which about 75% is run by private farmers. Therefore, the importance of agroforestry in pulp and paper production is significant.

The increasing area under agroforestry can help to address some of the major challenges arising due to climate change in the country (Dhyani et al., 2016; CAFRI Vision 2020). However, the agroforestry scenario of the country is dominated by Eucalyptus, Subabul, Casuarina, Gmelina, Teak, Shisham and Poplar. Of these, Eucalyptus (*Eucalyptus globulus* L.) and Subabul (*Leucaena leucocephala* L.) are the most popular and occupies a major area under agroforestry in India. These tree species have a tremendous scope in pulp and paper making industries in India. Eucalyptus is one of the most planted woody species in the world (FAO 2006) found in most of the states of India. Though there were sporadic Eucalyptus plantation in Andhra Pradesh (including Telangana State) since the year 1874, it was only around 1960 that regular Eucalyptus plantations were raised in a large extent. Mechanized Eucalyptus plantations raised for industrial use in Uttar Pradesh resulted in Internal Rate of Returns (IRR) ranging between 29.2 to 49.12 for 8 to 10-year old crop. Under

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agroforestry conditions, block plantations of Eucalyptus gave an IRR of 49 to 62.5% in about 8 years, and for bund planting the Benefit:Cost Ratio (BCR) was 1.55 and 2.27 in about 8 years (Mathur *et al.*, 1984). The success of Eucalyptus planting in the government land attracted farmers to this species. The *Subabul* sp. is a multipurpose sustainable leguminous tree grown in the southern and central states of India, with a huge positive socio-economic impact on the livelihood of small farmers.

Thus, it provides an alternate crop choice to the farmers of Telangana (Semi-arid) and Andhra Pradesh (Sub-humid) states of India, where they are mainly growing cotton and chillies. Studying the cost-benefits, opportunity costs, problems, and perception of farmers in detail provides an opportunity to understand and further improve the potentiality of the agroforestry system in the country besides achieving environmental risks. Therefore, the present investigation focuses on the major objectives (i) economic analysis of Eucalyptus and Subabul in different districts of sub-humid and semi-arid (ii) risk and problem analysis of Eucalyptus and Subabul tree crops and (iii) study of farmers' perception about continuing cultivation of tree crops.

## 2. METHODOLOGY

### 2.1 Locale of the study

This study was conducted during the year 2019-20 and the study area comprises of three districts from each state (Telangana and Andhra Pradesh) for the present investigation (Figure 1). The details of major agricultural and horticultural crops grown in each district and the major soil types of the study area is illustrated in Table 1.

### 2.2 Economic analysis

#### 2.2.1 Selection of farmer respondents

A total of 465 farmers were contacted in six districts of sub-humid and semi-arid where tree crop cultivation was popular (Table 2). The information on the cultivation of Eucalyptus and Subabul were collected by administering a pre-tested questionnaire. Further, information related to alternative crops grown in the

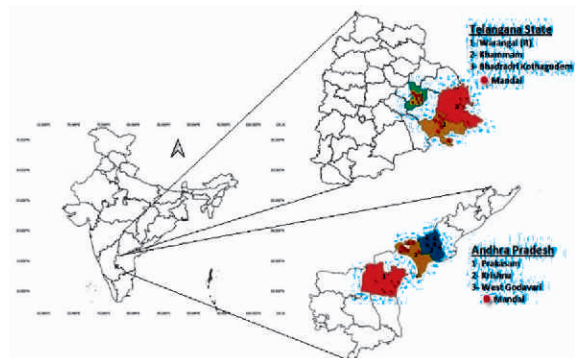


Figure 1: Location of the study area

location was also collected. Farmers' opinions and perceptions were recorded for analysis. Proportionate random sampling technique was employed in selected districts *i.e.* proportionate to the area under cultivation of the tree crops.

#### 2.2.2 Economics of alternative crops

The data relating to the cost of cultivation of Paddy, Cotton and Oil palm were calculated from the primary data collected during the survey. However, the data related to that of other alternative crops grown such as Blackgram, Maize and Bengal gram were compiled from Statistical Year Book 2017-18 of Semi-arid region.

## 2.3 Analytical tools used

### 2.3.1 Cost of cultivation

Cost concepts as devised by the Commission for Agricultural Costs and Prices (CACP) was used for the Economic analysis.

The indicators on which data were collected and their method of evaluation were as follows:

**Cost A1** It includes all actual expenses in cash and kind in production by the owner farmer as i) Value of hired human labour; ii) Value of hired bullock labour; iii) Value of machine labour, owned and hired; iv) Value of owned bullock labour; v) Value of owned machinery; vi) Value of hired machinery; vii) Value of seed (a) farm produced & (b) purchased; viii) Value of insecticides and pesticides; ix) Value of manure (owned and purchased); x) Value of fertilizers; xi) Depreciation of implements and machinery; xii) Irrigation charges; xiii) Land revenue; xiv) Interest on working capital; xv) Misc. Expenses (artisans *etc.*).

**Cost A2** Cost A1 + rent paid for leased-in land.

**Cost B** Cost A2 + rental value of owned land (net of land revenue) & interest on owned fixed capital excluding land.

**Cost C** Cost B + imputed value of family labour.

### 2.3.2 Imputation of Costs

The valuation of purchased inputs could be made based on the expenditure incurred, there were problems concerning some of the inputs used in the production of crops supplied by the farm family itself.

### 2.3.3 Risk Analysis

The risk was measured in terms of coefficient of variation (CV), a statistical measure that is not influenced by the unit of measurement. The decision criterion was taken as 30 per cent. That is, if the CV is less than 30 per cent, then it is termed as 'Less Risky' while CV above 30 per cent is marked as 'More Risky'.

**Table 1: Gross cropping area, cropping intensity, major agricultural and horticultural crops and soil types of sub-humid and semi-arid region.**

Region	District	Geographical area ('000 ha)	Gross cropped area ('000 ha)	Cropping Intensity (%)	Agricultural crops	Horticultural crops	Soil types
Sub-humid	Prakasam	1762.6	590.2	107.7	Chickpea, paddy, redgram, tobacco, cotton, sunflower, bajra and groundnut	Orange, banana, mango, sapota, lemon, papaya, chilli, tomato, coriander	-Shallow Red soils (51%), Deep black cotton soils (41%), Sandy loamy soils (6%), Sandy soils (2%).
	Krishna	872.7	716.3	154.7	Paddy, blackgram, maize, cotton, greengram, sugarcane, chilli, redgram, tobacco, groundnut	Banana, mango, chilli, bhendi, turmeric, cocnut, oil palm, pillipesara	-Black Cotton Soils (57.6%), Red Soils (19.4%), Coastal Sandy Soils, Alluvial Soils, Saline soils.
	West Godavari	332.6	699.8	161.9	Paddy, blackgram, maize, greengram, sugarcane, chilli, redgram, cotton, tobacco, groundnut, sunflower, sesamum	Cashew, banana, mango, lemon, chilli, oilpalm, coconut	-Alluvial (33%), Sandy alluvial (30%), Deltaic alluvial (24%), Coastal sandy loams (7%), Heavy clays (5%), Saline soils (1%).
Semi-arid	Khammam	1602.9	497.4	109.7	Paddy, maize, cotton, greengram, redgram	Cashew, banana, mango, chilli, oil palm	-Red Chalka Soils (43%), Black Soils (29%), Dubba Soils (28%), Saline soils (0.7%), Alkaline soils (0.2%).
	Warangal	1284.6	609.8	129.5	Paddy, cotton, maize, groundnut, chilli, greengram, redgram, bajra, jowar, turmeric, bengal gram, other pulses	Mango, chilli, turmeric	-Shallow red chalka soils (50%), Black Soils (25%), Deep red chalka soils (20%), Problematic soils (5%).
	Bhadradi Kothagudem	1120.8	139.04	152.5	Redgram, greengram, maize, jowar	Mango, banana, cashew, coconut, oil palm, cacao, pepper	Chalaka (43%), Dubba (28%) and Black soil (29%).

Source: Statistical Year Book 2017-18- Telangana.

**Table 2: Number of farmers selected from each district**

Region	District	Mandal	No. of farmers
Sub-humid	Prakasam	7	94
	Krishna	7	67
	West Godavari	5	85
Semi-arid	Khammam	7	74
	Warangal	5	65
	Bhadradi Kothagudem	7	80

Note: Mandal: a subdivision of a district

### 2.3.4 Price Analysis

Normalized Index and Relative Index were calculated to assess the price trend of wood (debarked) in comparison with other commodities like Chilli, Black gram, paddy, maize and cotton. The normalized index is calculated with the base of 2006-07. The relative price index is calculated with the base of 2006-07 and 2014-15 for various analyses. This index is calculated as the price of selected commodity divided by the price of debarked wood and presented as a percentage.

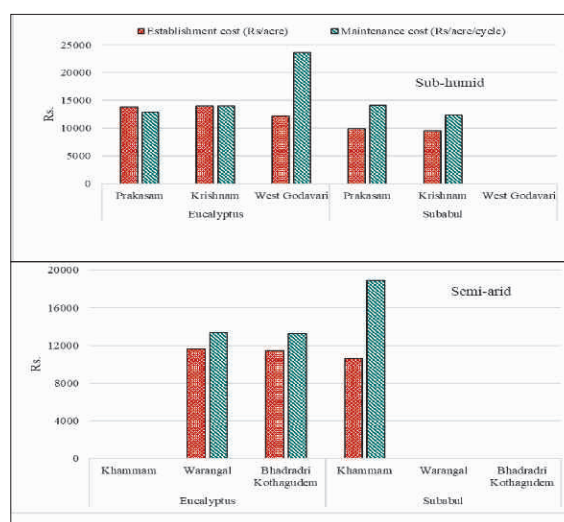
### 2.3.5 Weighted Scores

For understanding the problems in the cultivation of tree crops, the respondents were asked to identify the major problems. Then the total weights were calculated as the weighted sum of the value assigned by the respondents.

## 3. RESULTS AND DISCUSSION

### 3.1 Establishment & maintenance cost of Eucalyptus and Subabul in different districts of sub-humid and semi-arid

The cost of establishing one acre of Eucalyptus and Subabul varied with different districts. It ranged from 11431 to 14076 INR/acre and 9508 to 10609 INR/acre respectively for Eucalyptus and Subabul plantations (Figure 2). A maximum establishment cost of Eucalyptus and Subabul was recorded in the Krishna and Khammam districts. Eucalyptus crop has a cycle of about 4 years and normally it is coppiced two times for each plantation. The total cost of maintenance of the Eucalyptus for one cycle varied from 12871 to 14073 INR/acre/cycle (Figure 2). However, in West Godavari, maintenance cost of Eucalyptus observed to be very high (23638 INR/acre/cycle) compared to other districts. In Subabul crop, the cycle is considered to be about 3 years, in some places, the crop is harvested in two and a half years, while in other cases ranging from three to three and a half years. The maintenance cost of Subabul varied from 12332 to 18898 INR/acre/cycle (Figure 2). In Khammam, the maintenance cost of Subabul was found to be pretty higher as compared to others. However, in comparison

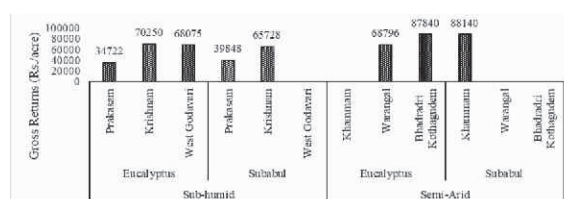


**Figure 2: Establishment & Maintenance cost of Eucalyptus and Subabul in different districts of Sub-humid and Semi-arid regions**

with Eucalyptus, the establishment cost of Subabul is considerably lesser but the maintenance cost is observed to be relatively similar. In both cases, the maintenance cost was very high during the first year as compared to subsequent years. Once the Eucalyptus crop is established, it can be coppiced and continued for about 12 years, on average. Hence, the establishment cost is amortized for 12 years and used in the calculation of fixed costs. During the first year, some farmers were using only herbicides while some resort to manual weeding. In the second and subsequent years, weeding is rarely done. Though this crop does not require plant protection chemicals, in the initial years, some farmers were going for it as they want to protect the plant against wilt. Despite this, some farmers perceived the cause of drying and death of few trees due to wilt pathogens. The establishment cost of Subabul is amortized for 12 years and about 4 cycles of 3-year was raised.

### 3.2. Returns Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions

Gross returns from the Subabul plantation were recorded to be maximum compared to Eucalyptus (Figure 3). In Khammam, Subabul yielded the highest gross returns amounting to 88140 INR/acre which was about 34 and 121% higher than the gross returns obtained in Prakasham and Krishna respectively. In case of Eucalyptus, Bhadradi Kothagudem recorded maximum gross returns (87840 INR/acre) followed by



**Figure 3: Returns of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions**



Krishna (70250 INR/acre). However, the least gross returns from Subabul and Eucalyptus (39848 and 34722 INR/acre respectively) were observed in Prakasham.

### 3.3 Profitability of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions

We observed that A1 cost is less and the costs A2 and cost B were very high (Table 4) among all the districts. In Prakasham, though the business is profitable considering the cost A1, it is a loss proposition considering returns over costs A2 and B. It can be inferred that if the farmer is not realizing profits over Cost A2, s/he will go for alternate options like leasing out or growing other profitable crops. In Krishna, despite lower cost in terms of A1, very high Cost- B indicates high opportunity cost of the land in terms of the lease. The returns over Cost A1 is very attractive, however, less profit over Costs A2 & B for Subabul indicate the crop is sustainable in the long run in this district. Negative returns from Eucalyptus indicates farmers may move away from the cultivation of this crop in case the prices have not turned favourably shortly. The lease value was about 14,000 INR/acre/year. In West Godavari, the cost A2 was very high as compared to Cost A1 which indicates the lease value of the land was very high (12,138 INR/acre). The negative profits over costs A2 and B indicate, at given price level, there is no incentive for the farmer to grow this crop. In Khammam, the out-of-pocket expenses for the cultivation of Subabul were 21,735 INR while cost A2 was 68,736 INR which indicates that opportunity cost of land was high in terms of lease value. However, this crop yield profit over costs A2 and B which proves

that it more than pays back the lease value and opportunity cost of the capital. This crop, given the price level, is a sustainable venture in the area. In Warangal, Eucalyptus was yielding reasonable profit over cost A1 which worked out to about 13,000 INR per annum and when the opportunity costs of land and capital were considered, still this tree crop was profitable indicating that it can sustain in the long run. In Bhadradi Kothagudem, the Eucalyptus crop yielded a profit of about 70,000 INR/acre over cost A1 and also yields reasonable profit after accounting for opportunity costs of land and capital in terms of lease value and interest on capital invested

### 3.4 The opportunity cost of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions

In Prakasham district, we observed that net profit calculated based on the farm gate price of crops like Blackgram, Chickpea, Tobacco and Chilli showed that field crops are more profitable than tree crops (Table 5). In Krishna, higher net profits of single-season alternative crops outweigh the returns of the tree crops. This indicates that Eucalyptus and Subabul cannot replace food or fibre crops in terms of returns. Similarly, in West Godavari, owing to its fertile soil, many crops such as Tobacco, Oil palm, Paddy and Maize were grown in this area during one season only. Tree crops fare very poorly in terms of returns in this area. In Khammam, when the profitability of Subabul is compared with field crops, Subabul is found to be more profitable than Cotton and Paddy. Hence, this crop may expand replacing some of the crops if the farmer does not account for the declining trend in the prices of wood. If annualized costs are compared, tree crops have the lease costs and hence, less risky. In Warangal,

**Table 4: Profitability (values in INR) of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions**

Sub-humid							
	District	Cost A1	Cost A2	Cost B	Profit over A1	Profit over A2	Profit over B
Eucalyptus	Prakasam	17391	49935	58060	17331	15213	23338
	Krishna	19138	75710	83974	51112	-5460	-13724
	West Godavari	23958	72510	79684	44117	-4435	-11609
Subabul	Prakasam	16662	41070	45448	23186	-1222	-5600
	Krishna	14825	57254	61441	50903	8474	4287
	West Godavari	-					
Semi-arid							
Eucalyptus	Khammam	-					
	Warangal	17594	56118	62953	51202	12678	5843
	Bhadradi Kothagudem	17343	47383	54093	70497	40457	33747
Subabul	Khammam	21735	68736	73407	66405	19404	14733
	Warangal	-					
	Bhadradi Kothagudem	-					

Table 5: Opportunity cost of tree cultivation in different districts of Sub-humid and Semi-arid

District		Sub-humid						Semi-arid												
		Gross Returns (INR/ac)			Net Profits (INR/ac)			Gross Returns (INR/ac)			Net Profits (INR/ac)									
		Black gram	Chickpea	Chilli	Tobacco	Eucalyptus	Subabul	Black gram	Chickpea	Chilli	Tobacco	Eucalyptus	Subabul	Black gram	Chickpea	Chilli	Tobacco	Eucalyptus	Subabul	
Prakasam		54840	46265	202500	67290	8681	13283	30942	29089	91250	17253	4306	7729							
Krishna		Cotton	Paddy	Eucalyptus	Subabul			Cotton	Paddy	Eucalyptus	Subabul									
		35404	35409	17563	21909			14752	10730	12778	16968									
West Godavari		Tobacco	Oilpalm	Paddy	Maize	Eucalyptus		Tobacco	Oilpalm	Paddy	Maize	Eucalyptus								
		133300	60250	3800	48490	17019		92061	22450	11515	28500	11029								
Khammam		Chilli	Cotton	Paddy	Subabul			Chilli	Cotton	Paddy	Subabul									
		138050	35404	39107	29380			74620	14750	11850	22135									
Warangal		Cotton	Paddy	Eucalyptus				Cotton	Paddy	Eucalyptus										
		36218	37980	17199				15090	11510	12801										
Bhadradri Kothagudem		Cotton	Paddy	Eucalyptus				Cotton	Paddy	Eucalyptus										
		32271	37500	21960				13446	11363	17624										

considering the alternative crops which are dominant in the selected district like Cotton and Paddy. Eucalyptus found to be as profitable as the field crops. However, considering the cost, cultivation of Eucalyptus found to be more risk-free in this district also by considering the present price level of these crops. This shows that there is ample scope for expansion of the Eucalyptus crop in Warangal. In Bhadradri Kothagudem, when the profits of Eucalyptus are compared with that of Cotton and Paddy, Eucalyptus found to be more profitable than field crops and also less risky as the cost of cultivation was also very less.

### 3.5 Problems in the cultivation of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions

Price fluctuations (score: 574) have been recorded as the major constraint followed by water (score: 287), marketing (score: 178) and labour scarcity (score: 152) in the cultivation of tree crops (Table 6). At disaggregate level, at Prakasam district, water problems, price fluctuations and marketing problems were the major problems. The farmers expressed that the tree crops were responsive to irrigation or rain and situations like drought. The continued dry spells reduced the yields of Eucalyptus greatly from about 25–30 tonnes to about 8–10 tonnes. Similar situation is observed in case of Subabul in the selected districts. The other problems were the quality of seedlings and pest incidences. The price fluctuations and inadequacy of irrigation water were the most important problems in Krishna district. Farmers preferred to grow this crop because of its stable price. However, presently these crops have become riskier. In West Godavari, price fluctuation was the main problem. Yet, farmers also expressed that labour problem was acute in this area due to which they were not taking up intercropping. Very few were going for intercropping and they try mostly during the first year of planting tree crop owing to availability of good sunshine. Marketing was also a major problem as they expressed that there is a six-month delay in getting the cutting order. In Khammam, price fluctuations, inadequacy of irrigation water and scrupulous activities by intermediaries/ middlemen were major issues. The intermediaries in this area were making it difficult for the farmers who want to transport wood on their own vehicles. Farmers at Warangal too expressed that price fluctuation is the main problem. They also could have related it to price cycles and felt that it is difficult to decide on how much area to put under this crop instead of

**Table 6: Problems in the cultivation of tree crops in different districts of Sub-humid and Semi-arid**

Sector	Problems	Scores						Total
		Bhadradri	Khammam	Krishna	Prakasam	Warangal	W.Godavari	
Marketing	Price Fluctuations	95	53	118	93	113	102	574
	Marketing Problem / Delay in Purchase Order	63	24	27	34	8	22	178
	Low Price	7	0	24	0	11	19	61
	Middlemen Problem	0	28	8	0	8	7	51
Social	Water Problem(Irrigation, Delayed on set of Monsoon)	36	31	58	118	28	16	287
	Labour Problem	45	19	26	0	32	30	152
	Monkey Menace	0	26	8	0	12	6	52
	Pest Problem(Insect, Disease and Weed)	5	10	20	3	5	4	47
Technological	Poor Quality Seed and Seedlings	6	3	6	4	6	3	28
	Fire Accident	9	3	0	1	9	0	22
	Tenancy Problem, Fencing, High Investment, Problem With Neighbouring Farmers, Flood, Paper Mill Far away	4	11	5	0	0	2	22
	Transportation	3	0	2	0	0	6	11

uncertainties in prices. Labour problem, inadequacy of irrigation and monkey menace were the other issues. Monkeys were damaging the meristem tip of the tree during the initial stages which greatly affect the growth of trees. At Bhadradri Kothagudem, price fluctuation, issues in marketing and labour problem were observed as the major issues.

**3.6 Risk analysis of Eucalyptus and Subabul in different districts of sub-humid and semi-arid regions**

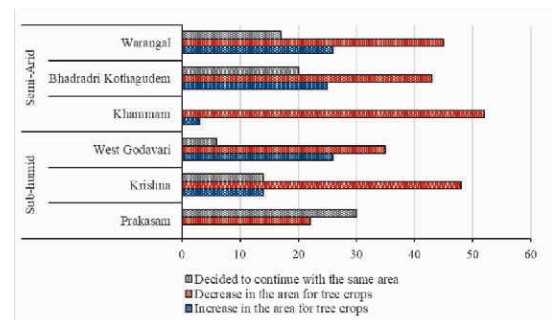
We observed that in a majority of the cases, tree crops are less risky (Table 7). However, the cultivation of Eucalyptus in Krishna and Prakasam districts and Subabul in Bhadradri and Krishna districts were found to be riskier. On the price front, since only the wood prices were available on a time scale (2005-06 to 2019-20), the analysis could not be conducted crop-wise. The CV of prices of wood is 42.25 percent and hence, was found to be riskier.

**3.7 Perception of farmers about continuing the cultivation of tree crops**

The farmers in the study area were asked the question: “In the near future, what you are planning to do?” to elicit information about how they perceive this crop and what they are planning for shortly. The results from figure 4 showed that none of the farmers in Prakasam expressed their willingness to increase the area under tree crop. A majority of the farmers in other districts were planning to reduce the area under tree crop. However, a considerable number of farmers at West Godavari, Bhadradri and Warangal were planning to increase the area under tree crops owing to acute shortage of labour in these areas.

**3.8 Comparison of movement of relative prices of alternative crops with that of wood**

The prices of commodities were indexed considering the base period as 2006-07 which showed that over about 13 years, wood prices have increased by about 2.5 times which was closer to that of Paddy, Maize and Cotton as depicted in



**Figure 4: Perception of farmers about continuing the cultivation of tree crops**

**Table 7: Risk analysis of tree crops**

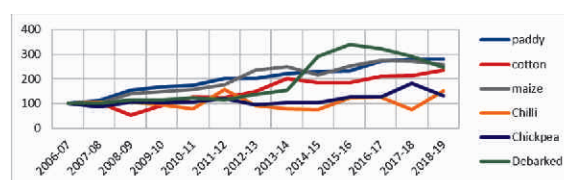
EUCALYPTUS				
Parameters	Districts	n	CV	Inference
Yield	Khammam	4	23.57	Less Risky
	Bhadradri Kothagudem	75	26.95	Less Risky
	Warangal	69	25.25	Less Risky
	Krishna	16	35.51	More Risky
	Prakasam	36	71.52	More Risky
	West Godavari	55	27.02	Less Risky
Price	Khammam	4	6.58	Less Risky
	Bhadradri Kothagudem	75	24.74	Less Risky
	Warangal	69	22.11	Less Risky
	Krishna	16	28.77	Less Risky
	Prakasam	36	68.94	More Risky
	West Godavari	55	32.79	More Risky

n= Sample size; CV- Coefficient of Variation

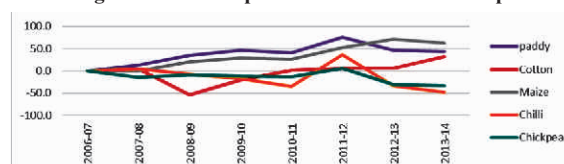
figure 5. While prices of Chilli and Chickpea have increased less than 50 per cent during this period. The relative prices were worked out as a ratio of commodity prices to wood prices and indexed to a base of 100 (Figure 6). Considering the base year 2006- 07, the relative prices of Maize and Paddy were found to be better than the wood prices. On the other hand, prices of Chilli and Chickpea were found to be performing worse than wood prices. While the Cotton price was fluctuating during this period. After the year 2014-15, prices were relatively unfavourable to tree growers. The prices of all alternative field crops have grown by at least 40 per cent as depicted in figure 7. This is one of the reasons why farmers are recently expressed their despair towards these tree crops.

#### 4. Conclusion and Recommendation

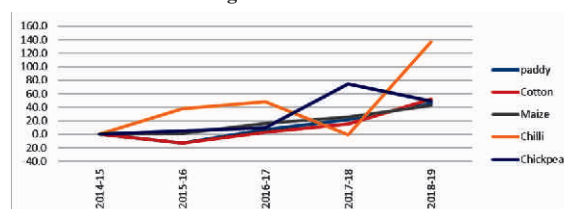
Promotion of agroforestry has a great potential in providing ecosystem services besides provisioning additional income to the growers. There is a great necessity of encouraging farmers of India to cultivate tree crops along with main field crops. In 2014, National Agroforestry Policy was launched in India to improve agroforestry-based livelihoods and contribute to the mitigation of climate change impacts. However, zone-specific policies under the government action plans on agroforestry are further needed to deal with climate change and the conservation of natural resources at the local level. As per this study on the perception of farmers, it was observed that there is positive response on increasing the area under tree crops but due to marketing issues, and other social/technical problems, ignorance is further increasing.



**Figure 5: Index of prices of wood and field crops**



**Figure 6: Relative price indices of field crops during 2006-07 to 2013-14**



**Figure 7: Relative price indices of field crops during 2014-15 to 2018-19**

- Eucalyptus and Subabul crops are long duration crops of about 3-4 years. Freefall in prices as it is happening for the last 5 years will affect both buyers and sellers adversely. Options like fixing minimum support price during sowing time or giving buy back guarantee can help in sustainable development of Agroforestry systems (through the formation of a regulatory authority, which controls cultivation of tree crops and comprising of representatives from all stakeholders including major paper mills).
- The new clones of Eucalyptus and Subabul grown by the farmers having self pruning of



branches & bark are preferred by the farmers. However, in some areas, farmers reported that these new varieties were susceptible to wilt. It calls for research in this direction.

- Instead of the recommended density of 900i Eucalyptus saplings per acre, some farmers are adopting a very high density ranging from 1200-1500 saplings, which they believe will yield more wood when the harvest cycle is reduced to about 2.5 to 3 years. Scientifically, it is not a good practice to put pressure on soil fertility & productivity and the quality of wood produced will also be affected. Thus, need to create awareness and sensitize the farmers on adoption of recommended spacing for raising pulpwood plantations.
- Middlemen's role has increased in recent years due to expansion of wood based industries. There is a need for standardization of harvesting & transportation expenses location wise, continuous monitoring and communicating these rates to the farmers and/or formation of farmer producer organizations (FPOs) will help & stop the exploitation of farmers by some middlemen.
- Farmers have expressed that the cultivation of tree crops is relatively risk-free. To hold them in the cultivation of tree crops, a minimum guaranteed buy-back price for a future date need to be offered to them. This will avoid irregular supplies in the future.
- Technology for better wood productivity and quality need to be transferred and premium for better wood quality can fetch a better price.

#### 4 CONFLICT OF INTEREST

Authors declare that there is no competing interest.

#### 5 ACKNOWLEDGEMENT

Authors are highly grateful to the ITC Limited, Hyderabad for funding this project.

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