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RESEARCH

DETERMINANTS OF FARMERS DECISION FOR ADOPTION AND NON-ADOPTION OF EUCALYPTUS PLANTATION AND THEIR IMPACT ON GROUND WATER LEVEL OF BORE WELLS IN MIDDLE GUJARAT

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Abstract: Probability of the farmer's decision in adopting eucalyptus was positive and significantly influenced by credit facility, per capita income, land not suitable for agriculture and land ownership. Age and family size was negatively influenced adoption decision of eucalyptus plantation.The impact of eucalyptus plantation on ground water table in western part of country was observed that average depth of bore wells was high (95.65 feet) within <1 km area of eucalyptus plantation. The study indicated that the depth of water table and percentage change in between present water depth and water depth before 3-5 year of bore wells within 1 km area of eucalyptus plantation was more than area of 1 to 3 km area. Similarly, fresh dug bore wells depth within 1 km area of eucalyptus plantation was more as compared to fresh dug bore wells within 1-3 km area of eucalyptus plantation.

Keywords: Eucalyptus, Adoption, Non-adoption, Bore well, Ground water level

INTRODUCTION

Agro-forestry systems offer an economical and ecologically viable option for large-scale diversification in agriculture on one hand and environmental amelioration on the other hand (Chauhan, *et al*., 2010). For the majority of crops, the actual value of production per hectare increased recently; however, the growth in input costs was far greater, resulting in lower farm revenue. To save forests and meet growing demands of wood, there is need for large scale plantations of fast-growing tree species outside forests to make country self-reliant in its timber requirements (Dogra, 2007; Tomar, 2015). Eucalyptus planting in India started taking shape through extension activities in the late sixties and early seventies. It gradually gained momentum in all parts of India, especially in Punjab, Haryana, western Uttar Pradesh, Gujarat, Tamil Nadu, North Bengal and Andhra Pradesh. After mid-eighties, eucalyptus plantations suffered a serious setback on many counts during eighties (Saxena, 1991).

After introduction of clonal technology in eucalyptus, productivity of eucalyptus plantation increase by two to three times and the rotation period was also reduced by approximately half. This also reduced the rotation time of farm forestry plantations from eight year to four year. Due to that, improvement planting of eucalyptus has again shown an increase in the 1990s and their production and growing stock in the non-forest areas has almost stabilized. India has 80.20 million hectare land under the forest and tree cover, which is 24.39 per cent of the geographical area of the country. India occupies 10th rank among the most forested countries of the World. Contribution of Gujarat was 273.3 lakh with 21.02 per cent of total eucalyptus plantation and 9.07 per cent of total non-forest tree population in India and total growing stock in Gujarat was 1180 lakh cubic meter out of which eucalyptus contributed 77.7 lakh cubic meters.Forests were once looked upon as a storehouse of timber and as unused lands available for development. Natural forests of the country will not be able to sustain increasing demand for wood and wood products. Therefore, we must move towards alternative sustainable wood production systems on a limited land area. Agro-forestry has received considerable attention in Gujarat with the object of integrating land use for agriculture and forestry to meet multifarious needs of society during past years (Rani *et al*., 2016).There are more than 700 species of eucalyptus available in world. Out of those, around 10 eucalyptus species are available in Gujarat. *Eucalyptus tereticornis* was preferred to other exotic trees because of short-term visible gains for straight bole, fast growth rate, more productivity per unit area and least post-plantation care (Mathur *et al*., 1984). Eucalyptus wood is used for timber, firewood, and pulpwood and pole purpose. It can be easily raised and has fast growth habits. Therefore, the farmers have accepted nilgiri with open arms. In the last few years, clonal plantation of eucalyptus has

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started and found in substantial numbers in the study area.

In recent time due to the lower danger of wild animal, insect, and disease attacks, as well as the possibility to be produced even on marginal areas, the cultivation of diversified crops such as medicinal and aromatic plants, perennial crops etc.,was chosen as a substitute crop for more commonly planted crops by the farmers (Saran *et al*., 2018). In field crops, the issues that small and marginal farmers now facesuch as labor shortages, inadequate irrigation, unsuitable land for farming, wild animals, etc., can be resolved by using long-term crops. The long-duration crops only needed a one-time investment; thereafter, they could manage with minimal input, and finally, they would provide large profits. (Changela and Devi, 2020). In recent years, growing of eucalyptus becoming popular and there are very limited studies conducted on eucalyptus cultivation and ground water table. Hardly any respondent study is available, particularly in Gujarat, on impact evaluation with particular focus on ground water availability.

METHODOLOGY

Data collection

Primary data were collected from sample households through personal interview by survey method with the help of pretested structured schedules during the year 2018-19. There are 33 districts in the Gujarat state. Among them Ahmedabad, Anand, Vadodara, Kheda, Panchmahal, Dahod, Botad, Mahisagar and ChhotaUdepur are covered under Middle Gujarat region. The Middle Gujarat region of the state was selected for present study as it contributed 30.05 per cent of total tree population in Gujarat during 2013. Whereas, the total eucalyptus plantation contributed 18.50 per cent out of total tree population in Gujarat.Out of nine districts in the middle Gujarat, three districts namely Dahod, Panchmahal and Anand were selected purposively on the basis of concentration of total eucalyptus population. From each selected districts, two talukas were selected on the basis of availability of eucalyptus farmers. From Dahod district Limkheda and Devgadhbaria, from Panchmahal district Godhara and Kalol taluka and from Anand district Anand and Borsad taluka were selected for detailed study. Thus, total six talukas were selected for the present study. From each selected taluka 20 eucalyptus grower were randomly selected. Therefore, total 120 (20×6) eucalyptus growers and 60 (10×6) non-eucalyptus growers were selected to achieve the stipulated objectives of the study. Thus, total 180 respondents were selected for detailed study.

Logistic Regression Model

Logistic regression model was used to studythe determinants of farmer's decision making for eucalyptus plantation. A logistic regression model was use empirically to quantify the relative influence of various factors in the decision of the respondents to adopt eucalyptus plantation or non-eucalyptus plantation. It was assumed that the probability of a farmer adopting eucalyptus plantation (Li) depends on the attributes like age of the respondent (years), education level (years), per capita income, availability of land not suitable for agriculture *etc*., The index variable Zi indicates whether a farmer is adopting eucalyptus plantation or not has been expressed as a linear function of the independent variables.Thus, the logit regression model was specified as following Equation:

$$Li = In\left[\frac{p_i}{1-p_i}\right] = Z_i = \beta_0 + \beta_1 X_1 +$$

$$\beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n + U_i$$

Where,

[P_i =probability of being an adopter of eucalyptus tree ranges from 0 to 1, Z_i= Function of "n" explanatory variables (x), L_i = log of the odds ratio, X_1= Age, X_2 = Family size, X_3 = Education, X_4 = Credit facility, X_5 = Farm size, X_6 = Income per capita, X_7 = Land not suitable for agriculture, X_8 = Land ownership, B_0 = Constant and U_i = Error-term]

The index variable Zi is a dichotomous variable, *i.e*. it takes the value of one if a respondent is adopting eucalyptus plantation (Zi=1) and takes the value zero otherwise (Zi=0).

Garrett Ranking Technique

To prioritize the major constraints faced by eucalyptus growers, Garrett Ranking Technique (GRT) was used. This technique helps in deciding the most important constraints faced by respondents in the order of priority. GRT is used to rank the choice of factors or reasons. According to this, the respondents were asked to assign rank to different problems. The order of merit thus given by the respondents converted into ranks by using the following formula:

$$\text{Percentage Position} = \frac{[100(R_{ij} - 0.50)]}{N_j}$$

Where,

R_{ij} = Rank allotted for i^{th} problem by the j^{th} individual

N_j = Number of problems ranked by the j^{th} individual

The per cent position of each rank was thus converted into scores by referring to the table given by Garrett. Thereafter, for each problem, the score of individual respondents were added and divided by total number of respondents. The mean score for all the problems would arrange in descending order and thereafter ranks was assign to the problems.

Ground Water Availability

Opinion of the farmers was taken regarding impact on the ground water availability that is likely to occur due to plantation of eucalyptus around bore well water use regimes. The data were collected from freshly dug bore wells and existing bore wells (of 3-5 years' age) within 1 km distance and between 1-3 km

distances. There were compared with respective data of 3-5 years back, as collected from perceptions of the farmers. Collected data from the respective farmers were analyzed based on average, frequency and percentages to draw the valid conclusions.

RESULTS AND DISCUSSION

Reasons for Adoption and Non-adoption of Eucalyptus Plantation

The reasons for adoption of eucalyptus plantation by growers were presented in Table 1.Out of reasons identified by respondents, lesser problem due to wild animals was ranked first as in eucalyptus plantation due to there was no damage occurred by wild animals as compared to other field crops. Higher income with less farm management was ranked seconddue to crop cultivation require very less management for second and third year so farmers can manage with other occupations. The third rank was given to labour by fewer pests and disease incidence, land is not suitable for other crop and low cost of maintenance, respectively. However, Solanki (2014) reported less fertilizer requirement ranked first followed by less labour requirement in eucalyptus plantation atBardoli taluka of Surat districtonly. The price and yieldthat farmers receive for a crop are important factors in deciding whether to cultivate and expand it further (Deviand Jadav, 2020).

Table 1. Reasons for adoption and non-adoption of eucalyptus plantation by farmers

Sr. No	A. Reasons for adoption of eucalyptus	Total score	Per cent position	Garrett Score	Rank
1.	Higher income with less farm management	3518	29.32	61	II
2.	Less problem due to wild animals	1808	15.07	70	I
3.	Less pest and disease incidence	6535	66.68	41	IV
4.	Labour requirement is less	5462	45.51	53	III
5.	Low cost of maintenance	7040	82.82	32	VI
6.	Land is not suitable for other crop	7627	77.82	35	V
	B. Reasons for non-adoption of eucalyptus				
1.	More water consuming crop	974	36.82	70	II
2.	Effect on soil fertility	263	16.24	58	I
3.	Low finance availability	2209	54.90	48	III
4.	Non availability of market	3294	78.01	35	IV
5.	Lack of experience related toeucalyptus plantation	4212	84.83	30	V

The effect on soil fertility as the foremost reason for not adopting eucalyptus plantation on their farm followed by more water consuming crop as they observed in eucalyptus plantation (Table 1). Low finance availability, non-availability of market and lack of experience related to eucalyptus plantation were minor reasons for not adoption of this plantation. Solanki (2014) also ranked first factor to soil fertility followed by more water consuming crop at particular district. Poor quality (Saline) ground water has been also used by eucalyptus plantation except summer (Paul *et al*., 2010).

Logistic Parameters for Adoption of Eucalyptus Plantation

The estimated results of the logistic regression analysis revealed that probability of the farmer's decision in adopting eucalyptus was positive and significantly influenced by credit facility, per capita income, land not suitable for agriculture and land ownership (Table 2). Age and family size has negatively influenced on adoption decision of eucalyptus. Whereas, education and farm size were positive but statistically non-significantly influence to adoption of eucalyptus plantation. Khan *et al*., (2017) and Neupanea *et al*., (2002) the age of farmer had significant negative effects on the tree plantation. Credit facility is most important for adoption of eucalyptus plantation. Lerra and Tefera (2016) also indicated that loan and credit facility is a critical issue in eucalyptus tree plantation. Family income is one of the important factors for determining the farmer's decision in taking up or planting of the eucalyptus tree. Income per capita was positive and significantly increased the odds of the household's decision to use the land to plant eucalyptus trees versus the decision not to plant eucalyptus trees by a factor of 1.000. Ashraf, *et al*., (2015) and khan *et al*., (2017) reported that the monthly income of the farmers had significant and positive for the tree plantation adoptedby the growers. The farmer's that takes in non-farming land was most likely making a decision in adopting of the eucalyptus tree than the farmers who haven't the land not suitable for agriculture by the factor (13.38). The availability of land not suitable for agriculture hadpositive and significantly affectedthe farmer's eucalyptus plantation decisionas reported by Lerra and Tefera (2016). Significant relationship between land ownership and the decision to take on a eucalyptus plantation was observed. Land ownership is an important socio-economic characteristic which suggested that the farmers who owns his owned land is more likely to make positive decisions on adoption of the eucalyptus plantation by a factor of 117.91, while the land which the farmers managed through lease, rent or share-cropping, does not use for the tree

planting purpose. The similar findingon eucalyptus plantation was also reported by Lerraand Tefera (2016). Moreover, Devi *et al.*, (2023) reported that likelihood that the farmer would choose to use the rice variety GAR-13 was positively and significantly influenced by education, farm size, income, and credit availability; on the other hand, the likelihood was negatively and significantly influenced by the farmer's age, as younger farmers were typically more willing to take risks than older ones.

Table 2. Estimation of logistic parameter for adoption of eucalyptus plantation

Sr. No.	Particulars	b_i	Std. Error	p-value	Expectations β(odd ratio)
1.	Age (years)	-0.067**	0.028	0.017	0.935
2.	Family size (no.)	-0.208	0.122	0.089	0.813
3.	Education (years)	0.022	0.088	0.801	1.022
4.	Credit facility	1.996**	0.650	0.002	7.360
5.	Farm size (ha)	0.033	0.089	0.707	1.034
6.	Income per capita (□)	0.000**	0.000	0.004	1.000
7.	Land not suitable for agriculture	2.594**	0.726	0.000	13.388
8.	Land ownership	4.770**	1.382	0.001	117.911
9.	Constant	-3.111	2.732	0.255	0.045
-2Log Likelihood		94.81			
Percentage Correct		88.30			
Chi square ($\chi 2$)		134.336**			
Nagelkerke R^2		0.730			
Count R^2		0.88			
No. of observations		180			

Impact of Eucalyptus Plantation on Water Table

Percentage change in depth of water table in 3 to 5 years oldbore wells around eucalyptus plantation was presented in different districts of Gujarat (Table 3). The percentage change in overall water depth before 3-5 year and present water depth was 28.01 within 1 km area of eucalyptus plantation. Thehighest percentage change wasobserved in Anand (30.09 per cent) district followed by Panchmahal (26.78 per cent) and Dahod (27.17 per cent). Whereas, in case of within 1-3 km area of eucalyptus plantation percentage change in overall water depth before 3-5 year and present water depth was 24.22 and highest percentage change was observed in Anand (28.29 per cent) followed by Dahod (22.87per cent) and Panchmahal (21.51 per cent) district. The maximum fall in water depth of wells was in Panchmahal (16.65 m), Dahod (8.26 m)and Anand(6.7 m) districts in last ten years (2006-2015) as reportedin ground water year book during 2016-17.This might be due to greater ground water was usedby eucalyptus plantation as compared to total annual rainfall received under southern Indian conditions (Calder *et al.*, 1997).Therefore, eucalyptus could be cultivated near water stream to lower down the water level due to high water losses by leaf surface (Bari and Schofield, 1992).

Table 3. Impact of eucalyptus plantation on water depth of bore wells

Sr. No.	Districts	Water depth before 3-5 year (ft.)	Present water depth (ft.)	Change in percentage
A.	Bore wells within 1 km area of eucalyptus plantation (n= 36)			
1	Anand	43.17	61.75	30.09
2	Panchmahal	75.42	103.00	26.78
3	Dahod	90.25	123.92	27.17
	Mean	69.61	96.22	28.01
B.	Bore wells within 1-3 km area of eucalyptus plantation (n=24)			
1	Anand	41.50	57.88	28.29
2	Panchmahal	79.38	101.13	21.51
3	Dahod	90.63	117.50	22.87
	Mean	70.50	92.17	24.22

The details regarding percentage change in between fresh dug bore wells and old bore wells in area of eucalyptus plantation was presented in different crop growing districts of Gujarat (Table 4). The change between water table levels of fresh dug bore wells and old bore wells within 1 km area of eucalyptus plantation was 9.08 per cent.On an average the district wise the highest percentage change was

observed in Dahod (10.85 per cent) followed by Panchmahal (7.00 per cent) and Anand (8.86 per cent)districts. This may be due to higher eucalyptus plantation observed in Dahod as compared to other districts. The average change within 1-3 km area of eucalyptus plantation was 7.16 per cent. Among that highest percentage change in Dahod district (9.62 per cent) which was followed by Anand (7.03 per cent) and Panchmahal (4.22 per cent) district. Several studies have been reported that ground water was lower down significantly as compared with surrounding levels cultivated withother perennials (Paul *et al*., 2010).

Table 4. Impact of eucalyptus plantation on water depth of fresh and old bore wells

Sr. No.	District	Fresh bore wells water depth (ft.)	Old bore wells water depth (ft.)	Change in percentage
A.	Bore wells within 1 km area of eucalyptus plantation			
		n = 12	n = 36	
1	Anand	67.75	61.75	8.86
2	Panchmahal	110.75	103.00	7.00
3	Dahod	139.00	123.92	10.85
	Mean	105.83	96.22	9.08
B.	Bore wells within 1-3 km area of eucalyptus plantation			
		n = 12	n = 24	
1	Anand	62.25	57.88	7.03
2	Panchmahal	105.75	101.29	4.22
3	Dahod	130.00	117.50	9.62
	Mean	99.33	92.22	7.16

CONCLUSIONS

In conclusion the farmer's decision in adopting eucalyptus was positive and significantly influenced by credit facility, per capita income, land not suitable for agriculture and land ownership. Age and family size is negatively influenced on adoption decision of eucalyptus. Percentage change in bore wells depth within 1 km area of eucalyptus plantation was more as compared 1-3 km area of eucalyptus plantation. Fresh dug bore wells depth within 1 km area of eucalyptus plantation was more as compared to fresh dug bore wells within 1-3 km area of eucalyptus plantation.This clearly indicated that eucalyptus plantation lowering down the water table by up taking of ground water due to high annual transpiration rate in this region as compared to other perennials.

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