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Assessing Farmers' Perception of Agro-Forestry Practices in Gujarat, India

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ABSTRACT

Agroforestry represents a dynamic and ecologically grounded approach to managing natural resources. By integrating trees into farms and agricultural landscapes, it enhances production while fostering social, economic, and environmental advantages for land users across various levels. However, the expansion of agriculture in Gujarat has come at the cost of natural vegetation, notably forests, woodlands, and wildlife habitats. This study aims to evaluate societal attitudes toward agroforestry in Gujarat, specifically within the Dang, Saurashtra, Panchamahal, Tapi, etc. to explore various indigenous and traditional agroforestry practices. Primary data collection was conducted through self-administered questionnaires distributed via simple random sampling techniques among sample respondents. To achieve our objectives, data analysis utilized descriptive statistics, including frequencies and charts, as well as inferential statistics such as chi-square tests and logistic regression models. Furthermore, the study employed SPSS software for data analysis and output organization. The conservation and management of tree growth in agricultural and forested areas have been practiced among rural communities since the advent of settled agriculture, serving various purposes such as food, shelter, and ceremonial or religious significance. As indicated by the findings of our study, nearly half of the population expressed dissatisfaction with agroforestry practices. Significant variables affecting societal attitudes toward agroforestry include the educational background of individuals, environmental conditions, the location of tree planting, preferred planting sites, and motivations for planting trees on home compounds or farms.

Key words: *Agro-Forestry, Farmers' Perception, Gujarat*

Introduction

Agroforestry is any sustainable land-use system that maintains or increases total yields by combining food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and eco-logical conditions of the area (FAO, 2000). Agroforestry practices encompass various approaches, which can be broadly categorized into two groups: sequential methods like fallows, and simultaneous methods like alley cropping.

Among these practices, there exist approximately 18 different variations, each with its own unique characteristics.

To effectively implement agroforestry interventions as a component of rural development strategies, it is crucial to conduct research rooted in the understanding and perspectives of local farmers. Historically, many African farmers followed a practice of clearing land, utilizing it until its fertility diminished, and then relocating.

With the soil depleted and farmers moving elsewhere, a diverse array of trees and shrubs would naturally regenerate the area. Agroforestry is commonly practiced with the aim of promoting more efficient and sustainable land utilization to enhance farm productivity and uplift rural communities' well-being. The total area under Agroforestry in the world is 1023 mha. Maximum areas of Agroforestry in the world are found in South America (3.2 million square kilometre) followed by sub Saharan Africa that is 1.9 million square kilometre (Kumar *et al.*, 2014). Nevertheless, the adoption of Agroforestry continues to grow steadily.

In India, the reported area under Agroforestry was 7.4 million hectares in 2007, but by 2013, it had surged to 25.32 million hectares. Despite Gujarat covering 6.86% of its total geographical area with forests, it contributes only 13% of all timber, 5% of small timber (poles), and 18% of fuelwood consumption within the state. The remaining wood supply in Gujarat is sourced either from neighbouring states or collected from wastelands, communal grazing areas, and private properties. The densely populated and heavily industrialized belt of South Gujarat requires additional raw materials and timber to meet the escalating demands of its burgeoning population and industries. Hence, there is a pressing need to enhance the production of food, energy, fodder, and construction materials to adequately cater to the rapidly expanding population in this region.

The demand for forest resources, particularly for fuel and fodder, has escalated to such an extent that the rate of tree removal surpasses the annual growth of forests, leading to a swift depletion of forest cover. Given these circumstances, it is evident that solely addressing issues within the boundaries of these forests is insufficient to safeguard their survival. Rural communities have engaged in tree cultivation, conservation, and management on both agricultural and forested lands since the advent of settled agriculture, primarily for sustenance, shelter, and cultural or religious significance. According to recent literature, factors such as perceptions and attitudes towards trees, transaction costs associated with acquiring market information, production costs related to implementing and sustaining the technology, the advantages offered by the technology, sources of information, and demographic characteristics significantly influence the adoption of agroforestry practices.

Methodology

The data analysis method employed descriptive statistics and inferential statistics. Descriptive results were emphasized using frequency distribution and percentages. The Chi-squared test of association was used to explore the relationship between dependent and independent variables. Additionally, the logistic regression model was applied to identify societal attitudes towards Agro-Forestry practices. Multivariable logistic regressions were conducted, including all significant variables identified in the univariate analysis at a significance level of 25%. SPSS version 20 was utilized to perform both descriptive and inferential statistical analyses.

The research utilized primary data gathered through self-administered questionnaires completed by sampled respondents. Simple random sampling was employed, drawing from the target population (frame). This sampling technique was chosen because it provides every member of the population with an equal chance of selection. The study design adopted was a cross-sectional study, which involves observing various individuals (subjects) simultaneously, with each observation corresponding to a different individual at the same point in time.

The formula adopted for this study is;

$$n = \frac{no}{1 + no/N}$$

$$no = \frac{\left(\frac{z\alpha}{2}\right)^2 pq}{\mathrm{d}^2} = \frac{(1.96) * 0.5 * 0.5}{(0.1)^2} = 96.04 \sim 97$$

Where,

$Z\alpha/2$-desired level of confidence, 95%=1.96

α- level of significance= 0.05

d- Marginal error, d=10%

p- Proportion of sample, who is satisfy by service of agro-forestry, p=0.5.

q- Proportion of sample, who is not satisfy by service of agro-forestry.

N=4226-is total populations of the two ketene.

If no/N>0.05 we have to adjust, but if no/N

Descriptive Statistics

Descriptive statistics involve collecting, organizing, summarizing, and presenting data in meaningful ways through tables, charts, and graphs. These statistics are computed using measures of central tendency (such as mean, median, mode) and measures of variation (such as range, variance).

Inferential Statistics

Inferential statistics is a branch of statistics that uses data from a sample to make predictions or draw conclusions about a larger population. It uses statistical models and probability theory to test hypotheses and estimate population parameters. The goal of inferential statistics is to provide information about the entire population using sample data to make conclusions that are accurate and reliable.This process typically involves hypothesis testing, assessing relationships among variable estimates, and making informed decisions based on the results.

The Chi-square test

The Chi-square test is a statistical method used to analyze data obtained from categorical variables, typically in the form of counts. It relies on a Chi-square distribution, which is determined by its degrees of freedom. This distribution is right-skewed, and the random variable associated with it cannot take negative values. The primary objective of the Chi-square test of independence is to assess whether there is a relationship between two categorical variables or not.

$$5^2 = \sum \frac{(O_I - E_i)^2}{E_i}$$

Where

Eij= expected frequency for cell (i,j)

$$Eij = \frac{ni * n.j}{n}$$

ni.=ith row total

n.j= jth columns total

n = total sample size

Oij= observed frequency in cell (i,j)

The degree of freedom associated with contingency table possessing r-rows and c-columns= (r-1)(c-1)

Step 4. Finding the critical value (÷2 (r-1)(c-1),á)

Step 5. Decision rule

If ÷2 cal>÷ 2 (r-1) (c-1)á, then reject Ho, otherwise no enough evidence to reject the null hypothesis.

Step 6. Conclusion based on the decision

Logistic Regression Model

Satisfy or dissatisfy of some outcome events usually coded as 0 or 1) and the independent variables are continuous, categorical or both.

Binary Logistic Regression

Binary logistic regression is employed when the dependent variable is binary, such as the presence or absence of a specific event, and the independent variables can vary in type. In the context of a Bernoulli trial, the Bernoulli distribution characterizes the probabilities as P(Y=1) = π and P(Y=0) = 1 - π, where E(Y) = π.

The general model for binary logistic regression is as follows:

$$\log it\ ((\pi\ (xi)) = log\left[\frac{\pi(xi)}{1-\pi(xi)}\right] = \beta o + \beta_1 X_1 + \beta_2 X_2 + \ldots .. + \beta_K X_k$$

Where,

xi is an explanatory variable in the model,

π: the probability of success, 1-π: the probability of failure,

b*o* is constant terms/int

biis the coefficients or slope of the explanatory variable in the model.

Parameter Estimation for Logistic Regression

The two primary estimation methods utilized in fitting logistic regression models are maximum likelihood and non-iterative weighted least squares. When the assumption of predictor normality is violated, the non-iterative weighted least squares method proves less efficient. Conversely, the maximum likelihood estimation method is deemed suitable for estimating logistic model parameters due to its less restrictive assumptions. Therefore, in this study, the maximum likelihood estimation technique will be employed to estimate the model parameters.

The maximum likelihood estimates of the parameters can be acquired by maximizing the log-likelihood function, which is expressed as follows:

$$\pi\ (xi) = \frac{\exp(\beta o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_K X_k)}{1+\exp(\beta o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_K X_k)}$$

Since observing values of y say, y_i's (i = 1, 2…n) are independently distributed as Bernoulli, the maximumlikelihood function of Y is given by:

$$L\ (\beta/y) = \prod_{i=1}^{n} P\ (yi/xi) = \prod_{i=1}^{n} \left[\frac{e^{x_1\beta_i}}{1+e^{x_1\beta_i}}\right]^{yi} = \left[\frac{1}{1+e^{x_1\beta_i}}\right]^{(1-y_i)}$$

The Wald Test Statistic

The Wald statistic is frequently employed to assess the significance of individual logistic regression coefficients for each independent variable. It tests the null hypothesis in logistic regression that a specific logit coefficient is zero (i.e., $\beta i=0$) against the alternative hypothesis that it is not zero (i.e., $\beta i=0$) at a certain level of significance. The Wald test serves as a means of evaluating the significance of particular independent variables within a statistical model [40]. Wald $\chi 2$ was used to test the significance using the following formula:

$$W= \left(\frac{\beta}{se\ (\beta)}\right)^2 \sim \chi^2\ (1)$$

The Wald statistic, denoted as W, follows a $\chi 2$ distribution with one degree of freedom. The standard error of the regression coefficient χ is represented by se(β). The significance of the Wald statistic signifies the importance of the predictor variables in the model, and higher values of the Wald statistic indicate that the corresponding predictor variable is significant.

The Hosmer-Lemeshow Test

The final measure of model fit is the Hosmer and Lemeshow goodness-of-fit statistics, which evaluates the agreement between the actual and predicted values of the dependent variable. The Hosmer and Lemeshow test is a widely used method for assessing the goodness of fit of a model and accommodates any number of explanatory variables, whether continuous or categorical.

The Hosmer-Lemeshow test statistic is defined as follows:

$$C^2= \sum_{i=1}^{p} \left[\frac{(O_i - E_i)^2}{m_i p_i\ (1-p_i)}\right]$$

Where,

Oi, *Ei*, *mi*, *pi* are denotes the observed events,

expected, observations and, the average predicted risk for the

i^{th}risk desire group respectively.

The statistical hypothesis of the Hosmer Lemeshow test.

H1: The model is good to fit the data.

H0: The model is not good to fit the data.

The decision rule is we do not reject the null hypothesis if

the p-value >a value=0.05.

Results and Discussion

Descriptive statistics, such as frequency distribution, bar charts, and pie charts, are employed to elucidate the general characteristics of certain attributes in the study.

Upon examining the frequency table above, it is evident that the level of Agro-forestry practice within the society varies across different age groups of respondents. The highest percentage (32.6%) of individuals expressing dissatisfaction with the Agro-forestry practice level falls within the age group of 15-25, followed by the age group of 26-35. Conversely, the lowest percentage (10.9%) of individuals dissatisfied with the Agro-forestry practice level is found in the age group under 15.

Regarding the education status of the society, the level of satisfaction with Agro-forestry practices varies significantly based on the respondents' educational background. The highest proportion (76.1%) of individuals expressing dissatisfaction with Agro-forestry practices are found among the illiterate population. Conversely, the lowest proportion (23.9%) of dissatisfaction is observed among literate individuals. Moreover, only 29.4% of the satisfied respondents are illiterate, while the majority (70.6%) of satisfied individuals are literate.

Furthermore, satisfaction with Agro-forestry practices differs based on the location where trees are planted. Those who are less satisfied with Agro-forestry practices predominantly (56.6%) planted trees within their home compounds, whereas the lowest proportion (10.9%) of dissatisfaction is among those who planted trees in deforested areas nearby.

The choice of plant species also impacts the satisfaction level with Agro-forestry practices. The highest percentage (50%) of dissatisfaction is observed among those dealing with domestic plant species,

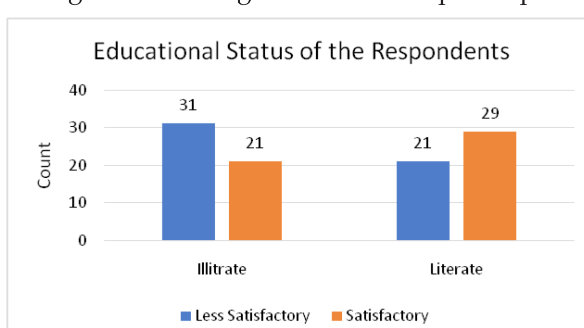

Fig. 1. Educational Status of the Respondents

Table 1. Summary descriptive statistics for categorical variable in Agro –forestry practice level.

Variable	Category	Agro-ForestryPractice					
		Satisfactory		Less Satisfactory		Total	
		Count	%	Count	%	Count	%
Gender	Male	36	70.6	21	45.7	57	58.8
	Female	15	29.4	25	5403	40	41.2
Fascination	Yes	49	96.1	46	100	95	97.9
	No	2	3.9	0	0	2	2.1
	Domestic	14	27.5	23	50	37	38.1
Variety	Wild	3	5.9	3	6.5	6	6.2
	Both	34	66.7	20	43.5	54	55.7
Learning Status	Illiterate	15	29.4	35	76.1	50	51.5
	Literate	36	70.6	11	23.9	47	48.5
	<15	3	5.9	5	10.9	8	8.2
Age	15-25	12	23.5	15	32.6	27	27.8
	26-35	20	39.2	14	30.4	34	35.1
	>35	16	31.4	12	26.1	28	28.9
	Home compound	11	21.6	26	56.6	37	38.1
Location of planttree	Farm boundary	13	28.3	17	33.3	30	30.9
	Around road	3	5.9	2	4.3	5	5.2
	Deforested area	20	39.2	5	10.9	25	25.8
	Home compound	16	7.8	9	19.6	13	13.4
Place prefers to plant	Farm boundary	4	32.2	7	13.7	22	22.7
	Around road	36	7.8	5	10.9	6	9.3
	Deforested area	47	70.6	17	37	53	54
	To obtain suitable condition	9	17.6	11	23.9	20	20.6
Reason to prefer the place	To protect erosion	23	45.1	17	37	40	41.2
	To protect external danger	4	7.8	8	17.4	12	12.4
	To keep fertility of soil	15	29.4	10	21.7	25	25.8
Ecological Conditions	Yes	40	78.4	43	93.5	83	85.6
	No	11	21.6	3	6.5	14	14.4
	Shortage o flabor	13	25.5	11	23.9	24	24.7
Problem tree production	Shortage of cash	18	35.3	15	32.6	33	34
	Shortage of equipment	10	19.6	1	2.2	11	11.3
	Knowledge	10	19.6	19	41.3	29	29.9
	Shortage of land	24	47.1	21	45.7	45	46.4
	Lack of tree product	14	27.5	7	15.2	21	21.6
Determining factors	Types of trees	6	11.8	10	21.7	16	16.5
	The use of tree	2	3.9	0	0	2	2.1
	Age planter	5	9.8	8	17.4	13	13.3
Animal Influence	Yes	24	47.1	20	43.5	44	45.4
	No	27	52.9	26	56.8	53	54.6
Tree on your farmor compound	Yes	49	96.1	43	93.5	92	94.8
	No	2	3.9	3	6.5	5	5.2
	For constriction	16	31.4	21	45.7	37	38.1
If your answer why	To obtain fuel	7	17.7	8	17.4	15	15.5
	To obtain wood	11	21.6	14	30.4	25	25.8
	To conserves species tree	17	33.3	3	6.5	20	20.6
	Forfuel	17	17.5	21	45.7	38	39.2
Purpose of tree	For constriction	21	40.2	17	37	38	39.2
	To wide plough land	13	25.5	8	17.4	21	21.6

while the lowest percentage (6.5%) of dissatisfaction is among those dealing with wild plant species. Conversely, the highest proportion (66.7%) of satisfaction is observed among those who work with both domestic and wild plant species.

When examining the educational status of the population as depicted in the above bar chart, it reveals that 50 individuals (49.01%) are literate. Among this literate population, 21 individuals (42.1%) express satisfaction with their agroforestry practices, while 29 individuals (58%) are dissatisfied. On the other hand, 52 individuals (50.9%) are illiterate, with 21 individuals (50.9%) indicating satisfaction and 31 individuals (59.6%) expressing dissatisfaction with their agroforestry practices.

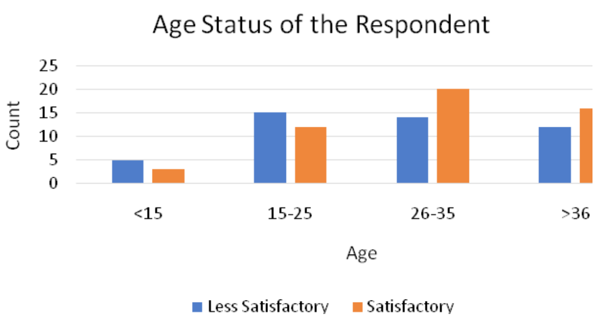

Fig. 2. Age Status of the Respondents

From the data presented in the above bar chart, it's evident that the age group most actively engaged in agroforestry within the society is the 26-35 range, comprising 34 individuals (33.7%). Within this age bracket, 20 individuals (59%) express satisfaction with their agroforestry practices, while 14 individuals (40.6%) indicate dissatisfaction. Conversely, the age group below 15 consists of 8 individuals (8.4%) and exhibits the lowest level of agroforestry engagement. Among this group, 3 individuals (37.5%) report satisfaction with their agroforestry practices, whereas 5 individuals (62.5%) express dissatisfaction.

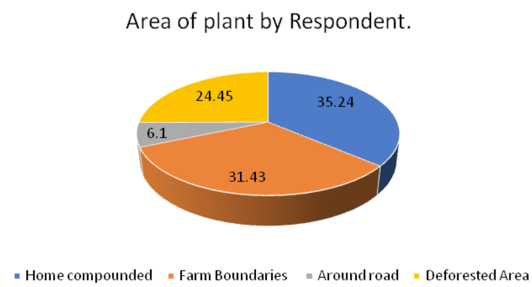

Fig. 3. Area of plant by the Respondents

According to the information provided in the pie chart, 35.24% of the surveyed societies plant trees on their home compound, while 31.43% plant trees along farm boundaries. Additionally, 6.1% of respondents plant trees around roads, and 24.45% plant trees in deforested areas. Therefore, based on the description provided by the pie chart, it is evident that a larger portion of the population prefers

Table 2. The best place the respondent prefers to plant tree.

	Value	df	Asymp.	Sig. (2-Sided)
Pearson Chi-Square	9.302[a]	3	0.007	
Likelihood Ratio	8.231	3	0.004	
	Value	df	Asymp.	Sig. (2-Sided)
Linear by Linear association	8.117	2	0.003	
N of Valid cases	86			

Table 3. The conduction of education of respondent

	Value	Df	Asymp.Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	19.096[a]	1	.000		
Continuity Correction	17.269	1	.000		
Likelihood Ratio	20.379	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-LinearAssociation	18.754	1	.000		
N of Valid Cases[b]	94				

to plant trees on their home compound.

Based on the information provided in the chi-square table, the Pearson chi-square value ($\chi2\_cal$ = 9.302) exceeds the tabulated $\chi2\_0.05(1)$ value of 3.841. Additionally, the corresponding p-value is calculated to be 0.007, which is less than the significance level α of 0.05. Hence, null hypothesis can be rejected. Consequently, we conclude that there is an association between the preferred planting locations of the respondents for future tree planting and the attitude of the society.

Based on the data provided in the chi-square table, the Pearson chi-square value ($\chi2\_cal$ = 19.096) exceeds the tabulated $\chi2\_0.05(1)$ value of 3.841. Additionally, the corresponding p-value is calculated to be 0.000, which is less than the significance level á of 0.05. Hence, we significantly reject the null hypothesis. Also, it can be concluded from the results that there is significant corelation between samples' education and societal attitude.

The Hosmer and Lemeshow test is used to assess the goodness of fit of a model. A large p-value from this test indicates that the model fits the data well, while a small p-value suggests a poor fit.

In this case, the p-value obtained from the Hosmer and Lemeshow test is 0.438. Since this p-value is relatively large, it indicates a good match between the model and the data. Therefore, the result of the test suggests that the model fits the data very well.

Table 4. Table of appropriate goodness of fit test for the logistic regression model Hosemer and Lemeshow Test.

Step	Chi Square	Df	p-value
6	5.320	6	0.438

Conclusion

From the analysis conducted, it is evident that the educational status of the population significantly influences their attitude towards agroforestry practices. Among the illiterate population, a significant majority (58.0%) express dissatisfaction with agroforestry, whereas only 42.1% of the literate population report satisfaction. This highlights the profound impact of education on societal attitudes towards agroforestry.

Contrary to expectations, the species of trees being planted does not seem to significantly affect societal attitudes towards agroforestry practices. A substantial portion (56.8%) of societies plant both wild and domestic tree species, indicating that the type of tree species does not play a significant role in shaping attitudes towards agroforestry.

However, the choice of planting location does appear to have a notable influence on societal attitudes towards agroforestry. Only a small proportion (6.1%) of societies plant trees around roads, while a larger portion (35.24%) prefer planting on their home compounds. Additionally, a considerable percentage (24.45%) of societies plan to plant trees in deforested areas in the future. This suggests that the selection of planting sites, whether it be on home compounds, farms, or deforested areas, significantly impacts societal attitudes towards agroforestry practices.

Variables such as the educational background of societies, environmental conditions, the chosen planting area, the preferred location for planting, and the reasons for planting trees on home compounds or farms emerge as significant factors influencing societal attitudes towards agroforestry. These findings underscore the multifaceted nature of attitudes towards agroforestry, which are shaped by a combination of educational, environmental, and spatial considerations.

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