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Article

Does Efficiency Matter? A Study on Factors Affecting the Technical Efficiency of Betel Nut Producers in Assam

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Abstract: Purpose- Betel nut (*Areca catechu*) is one of the major plantation crops grown in Assam. However, due to inefficiency in production, the productivity of betel nuts in the state is very low. Therefore, this study attempted to measure the level of technical efficiency and the factors affecting the technical inefficiency of betel nut growers in the Nagaon district of Assam. **Design/methodology/approach** – Primary data were collected from 240 households in the Nagaon district of Assam. Based on the Cobb-Douglas Production function for betel nut growers, the present study uses stochastic frontier analysis to estimate the production frontier and examine the effects of exogenous variables on farm-level technical inefficiency. **Findings** - The findings of the study reveal that, on average, 85 per cent of betel nut growers are technically efficient in the study area. Moreover, experience in betel nut plantations and gender have a significantly negative effect on technical inefficiency. In contrast, the age of the grower had a positive and significant effect on the technical inefficiency of betel nut cultivation. The findings suggest the availability of space for an increase in the productivity of betel nut plantations in the study area and scope for increasing the level of output through technical efficiency without raising inputs. **Originality/Value:** This study contribute to the estimation of the technical efficiency of betel nut growers and examines the factors responsible for technical inefficiency. The dataset is original and was especially collected for the present study.

Keywords: technical efficiency; Cobb-Douglas; maximum likelihood estimation; stochastic frontier analysis; D24; Q13

1. Introduction

Initially native to Malaysia, betel nut, *Areca catechu* were cultivated widely in other South and Southeast Asian countries, including India, Bangladesh, Myanmar, Taiwan, Sri Lanka, Thailand, Bhutan, Nepal, and the Philippines. Data on the production of betel nuts in India show that the country was the highest producer of betel nuts in 2019. India accounted for 52.3 per cent of the global areca nut production in 2019. In contrast, Bangladesh (18.4 per cent), Indonesia (8.7 per cent), and Myanmar (7.9 per cent) ranked second, third, and fourth, respectively, for betel nut production in 2019. However, Myanmar accounts for 56.6 per cent of global exports in 2020, with a U.S. \$ 111.68 million market value. While Sri Lanka (26.24 per cent and market value U.S. \$ 51.78 million), Indonesia (10.3 per cent and market value U.S. \$ 20.22 million) and India (5.23 per cent and market value U.S. \$ 10.31 million) ranked second, third and fourth positions respectively. In terms of import, it appears that India is the highest importer of betel nut (78.74 per cent and market value U.S. \$ 75.45 million), followed by China (4.78 per cent and market value U.S. \$ 4.58 million) and the United States of America (3.69 per cent and U.S. \$ 3.54 million). Thus, the data reveal that India remains the major importer of betel nuts, although it produced more than 52 per cent of the global betel nut in 2019. State-wise figures on betel

nut production in India show that Karnataka was the top-ranking state in terms of betel nut production in 2017 (63.16 per cent of total betel nut production in India). Kerala (15.88 per cent) and Assam (9.51 per cent) ranked second and third, respectively, in betel nut production during the same year. Table 1 provides an overview of betel nut production and yield in India during 2017.

Table 1. Production of betel nuts in India in 2017.

Sl. No	State	Area (in '000 Hectare)	Production (in '000 M.T.)	Yield Per Hectare	Production Share (in per cent)
1	Karnataka	254.64	517.35	2.03	63.16
2	Kerala	98.52	130.10	1.32	15.88
3	Assam	80.81	77.90	0.96	9.51
4	Meghalaya	16.93	24.99	1.48	3.05
5	West Bengal	11.55	22.85	1.98	2.79
6	Tripura	5.99	20.41	3.41	2.49
7	Tamil Nadu	6.50	10.14	1.56	1.24
8	Mizoram	11.86	7.27	0.61	0.89
9	Maharashtra	2.31	3.41	1.48	0.42
10	Andhra Pradesh	0.56	2.37	4.23	0.29
11	Nagaland	0.39	2.37	6.08	0.29
	India	496.65	832.98	1.68	100.00

Source: Horticulture Statistics Division, Department of Agriculture, Coopn & Farmers Welfare & Author's calculation.

Table 1 shows that the highest area under betel nut plantation was in Karnataka, followed by Kerala and Assam. As the case of production, however, the yield per hectare in Assam is very low among the major betel nut producing states in India. The highest yield was observed in Nagaland, followed by Andhra Pradesh, and Tripura. In Assam, the yield per hectare was only 0.96 metric tonnes. Betel nuts are major horticultural crop planted in Assam. As shown in Table 1, approximately 80.81 thousand hectares of land in Assam are under betel nut cultivation, which is 16.27 per cent of the total betel nut plantation area in India. In contrast, Assam produces 77.90 thousand metric tons of betel nuts - 9.51 per cent of the country's total production during 2017. Nagaon district produces the highest number of betel nuts in Assam. The district produced 15.1 per cent of the total betel nuts in Assam in 2013. The cultivation and production of betel nuts in Assam is labor-intensive and involves a large number of laborers. This provides direct and indirect employment opportunities for growers and traders. Thus, the efficient use of production inputs is critical for betel nut growers to minimize production costs and maximize profits. It is also crucial, to improve productivity and production from a policymaking perspective.

A low level of input utilization efficiency indicates a higher inefficiency of producers and vice versa. Hence, the estimation of technical efficiency and the study of the factors affecting it are critical from an economic perspective. Thus, this study estimates the technical efficiency of betel nut growers in Nagaon, a major betel nut producing district in Assam. This study uses stochastic frontier analysis (SFA) to measure the level of technical efficiency and discusses the factors that influence the level of inefficiency in betel nut production.

2. Objectives of the Study

The main objectives of this paper are:

- 1) To estimate the technical efficiency of betel nut growers in the study area.
- 2) To study the factors affecting the level of technical inefficiency in betel nut production in the study area.

3. Data Base and Methodology

This study used quantitative techniques to estimate the technical efficiency of betel nut farmers. Social, economic, and demographic variables are considered to determine the determinants of technical efficiency or inefficiency. The Nagaon district of Assam was purposively selected for this study because it has the highest betel nut production in Assam. The present study was based on primary data. However, secondary data were used to support this analysis. Primary data were collected through a direct interview method with the help of a questionnaire from 240 sample growers in the study area. In most agricultural studies, stochastic frontier analysis is used to determine technical efficiency in agriculture. Therefore, the stochastic frontier production function was used to determine the technical efficiency of the betel nut growers. The 'Frontier (version 4.1c)' computer programme is used to carry out the analysis.

4. Theoretical Framework of the Study

Many studies have found that many factors are responsible for technical inefficiency in producing different varieties of agricultural products. Inefficiency results from social, economic, environmental, and demographic factors. Kalirajan (1981) viewed individual farmer variability as the primary cause of yield variability, rather than random variability. Kalirajan (1984) used individual technical efficiency measures to identify the factors that cause variations in the level of efficiency among rice growers in the Philippines.

Kumbhakar et al. (1991) find that farmer education is essential for technical inefficiency. Moreover, their study revealed that large farms are technically more efficient than small- and medium-sized farms. However, a survey conducted by Adesina and Djato (1996) found no differences between educated and uneducated farmers. They also found that access to extension, modern varieties, and credit had no differences in the relative economic efficiency between small and large rice farms in Cote d'Ivoire.

Studies investigating technical, allocative, and economic efficiency have found that labor, herbicides, and fertilizers increase the level of production. In contrast, farmers' education, age, farming experience, and land size contribute positively and significantly to production efficiency (Parikh and Shah, 1995; Londiwe et al., 2014; Ali et al., 2019; Gogoi and Buragohain, 2019). The study made by Bravo-Ureta and Evenson (1994) found that the relationship between efficiency and various socioeconomic variables is not clear, and for which a clear strategy could not be recommended to improve performance.

Thus, from the literature, it was found that socioeconomic and demographic factors are the principal drivers of technical efficiency of growers of different crops. Existing literature suggests that both parametric and non-parametric approaches can be used to evaluate technical efficiency. Considering the merits and demerits of both approaches, the parametric approach, which allows us to use econometric techniques, was considered in the present study.

5. Stochastic Frontier Analysis

Stochastic frontier analysis (SFA) was independently developed by Meeusen and Broeck (1977) and Aigner et al. (1977). Considering the advantage of allowing for simultaneous estimation of individual technical efficiency of the respondent growers and determinants of technical efficiency (Battese and Coelli, 1995), the present study used SFA to estimate technical efficiency among the betel nut growers of the Nagaon district of Assam. Assuming that the stochastic frontier production

function follows the Cobb-Douglas form, a maximum likelihood estimation (MLE) is performed to determine the efficiency level. The Cobb-Douglas production function is the most used form of production in empirical studies on agriculture in developing countries (Abedullah et al., 2007; Ambalil et al., 2012; Ayaz and Hussain, 2011). Therefore, based on empirical studies, this study considers the Cobb-Douglas production function.

Following Aigner et al. (1977) and Meeusen and Broeck (1977), the stochastic frontier production function to determine technical efficiency and influencing factors can be expressed as:

$$Y_i = f(X_i; \beta) \exp^{(V_i - U_i)} \quad i = 1, 2, \dots, N$$

Here, Y_i is the output of the i^{th} firm, X_i is a vector of input quantities used by the i^{th} firm, β is a vector of unknown parameters to be estimated, and V_i is a random variable (independent of U_i) that is identically and normally distributed, which also captures the effects of statistical noise. U_i , assumed to capture technical inefficiency in production, is a one-sided nonnegative variable that follows a half-normal distribution.

In the present study, the production function considered is in a log-linear form and can be expressed as

$$\ln Y_i = \ln \beta_0 + \sum_{j=1}^N \beta_j \ln X_{ij} + V_i - U_i$$

Based on the level of input used by growers, the technical efficiency (T.E.) of betel nut growers is defined in terms of the ratio of observed output (Y_i) to the corresponding frontier output (Y_i^*). Thus, the technical efficiency of betel nut growers is as follows

$$\begin{aligned} TE_i &= Y_i / Y_i^* & (0 \leq TE \leq 1) \\ &= f(X_i; \beta) \exp(V_i - U_i) / f(X_i; \beta) \exp(v) = \exp(-U_i) \end{aligned}$$

The variances σ_v^2 and σ_u^2 , and the overall model variances are used to measure the total variation in output from the frontier under the following relationships:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad \text{and} \quad \gamma = \sigma_u^2 / \sigma^2$$

where γ = Total output variation from the frontier, which can be attributed to technical inefficiency (Jondrow et al. 1982).

The economic inefficiency levels of betel nut growers and the factors affecting them can be expressed using the following inefficiency model.

$$U_i = \delta_0 + \sum_{j=1}^N \delta_j(Z_j) \quad i = 1, 2, \dots, N$$

Here, U_i is the inefficiency of the i^{th} betel nut grower and Z_i represents the factors affecting the inefficiency of the i^{th} betel nut grower. Additionally, U_i follows a half-normal distribution because the half-normal distribution of U_i provides a marginally better fit than the exponential distribution of U_i (Aigner, Lovell and Schimdt, 1957).

5.1. Empirical Model Estimation

The existing literature suggests that social, economic, demographic, environmental, and institutional variables should be included in the models used to determine technical inefficiency factors. Some of the variables considered in the different studies were education, age, farming experience, access to credit, agricultural extension services, family size, gender, area under cultivation, irrigation, pesticide, and fertilizer. As in the study area, the growers follow the most traditional mode of production without access to credit (since it does not require much cost to cultivate the betel nut, the only requirement is land, labor, and seed), agricultural extension service (which is virtually absent for betel nut cultivation), and use of fertilizer (cultivators do not use fertilizer as the betel nut is traditionally cultivated). The present study considers family size, grower experience, education, age, and gender of the grower to determine the level of inefficiency.

However, since labor, area under cultivation, and plants under the orchard are the only factors used to cultivate and produce betel nuts, only the Cobb-Douglas production function was used with these variables to estimate the technical efficiency of betel nut growers. Thus, the stochastic frontier production model specified in this study can be expressed as:

$$\ln Y_i = \beta_0 + \beta_1 \ln(LAB)_i + \beta_2 \ln(BPLANT)_i + \beta_3 \ln(AREA)_i + v_i - u_i$$

$$i = 1, 2, 3, \dots, 240$$

where Y_i is the yield of betel nut per year; LAB_i is, use of labor by the i^{th} betel nut grower measured in man-days per hectare; $BPLANT_i$ is, number of betel nut trees planted per hectare by i^{th} betel nut growers; $AREA_i$ is, area under betel nut cultivation measured in hectares by the i^{th} betel nut grower; v_i represents an error term, $N(0, \sigma^2)$; u_i , half normally distributed as $N(0, \sigma^2)$; β_0 is the intercept; and $\beta_1, \beta_2, \beta_3$ are the parameters.

On the other hand, the Technical inefficiency model considered for the study is expressed as below:

$$u_i = \delta_0 + \delta_1 (FAMSIZE)_i + \delta_2 (BEXP)_i + \delta_3 (EDU)_i + \delta_4 (AGE)_i + \delta_5 (GENDER)_i + \varepsilon_i$$

where u_i is the technical inefficiency of betel nut yield; $FAMSIZE_i$ is the number of family members of the i^{th} betel nut grower; $BEXP_i$ is the experience of the i^{th} betel nut grower in betel nut cultivation; EDU_i , years of schooling of the i^{th} betel nut grower; AGE_i , age of the i^{th} betel nut grower; $GENDER_i$, Dummy for the gender of the i^{th} betel nut grower (1=male, 0=female); δ_0 is the intercept considered in the model; δ_1 to δ_5 represent parameters to be estimated; and ε_i , error term with $N(0, \sigma^2)$.

6. Results and Discussion

Table 2 provides a summary of the variables considered for betel nut growers in the Nagaon district of Assam. The average production of betel nuts per grower is 1034.74 kg per hectare. The mean number of man-days used per hectare of land was 8.396, whereas the average number of planted trees plated was 171.46. The mean cultivation was .531 hectares. The average size of the betel nut growers was 5.487, whereas the average farming experience of growers was 13.73 years. The data relating to education reveal that the average number of years of schooling is approximately nine years. The average age of betel nut growers is 55.53 years, indicating that the present generation does not consider betel nut cultivation a source of income. Finally, most betel nut growers were male (87 per cent).

Table 2. Descriptive statistics of quantities of inputs and outputs of the respondent.

Variable	No. of Observation	Mean	Minimum	Maximum
Y (kg/hectare)	240	1034.74	300	3863
LAB (man-days/ hectare)	240	8.396	3	33.75
BPLANT (numbers of tree planted/hectare)	240	171.46	52.5	675
AREA (hectare)	240	0.531	0.2	1.33
FAMSIZE (numbers)	240	5.487	1	14
BEXP (years)	240	13.73	5	36
EDU (years)	240	8.97	0	17
AGE (years)	240	55.53	30	78
GENDER (1=male, 0=female)			0	1

	240	0.87		
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Note: The figures in brackets show the units of measurement of the variables used in the stochastic frontier production function.

Table 3 presents the maximum likelihood estimates (MLE) of the production function of betel nut growers in the Nagaon district of Assam. It has been observed that the L.R. value is 13.9 and significant at 1 per cent level of significance. All variables considered in this study were statistically significant. The coefficient for labor per hectare is 0.626 and is significant at the 1 per cent level of significance. Thus, one unit increase in labor leads to an increase of 0.626 units in total production, which is consistent with the studies of Iraizoz et al. (2003) and Binam et al. (2004). The number of trees planted per hectare was also significant at the 1 per cent level with a coefficient value of 1.129, which implies that a 1 per cent increase in the quantity of betel nut trees planted increases the level of betel nut output by about 1.129 per cent, *ceteris paribus*. This result is consistent with Sultan and Ahmed's (2014) findings.

The area under cultivation is significant at the 10 per cent level with a coefficient value of 0.111, which implies that a 1 per cent increase in area under betel nut cultivation will lead to a 0.111 per cent increase in betel nut production. This result is consistent with those of Khan et al. (2010), Balde et al. (2014), and Fatima and Azeem (2015), who found that an increase in the area under cultivation increases the output level.

On the other hand, the inefficiency model shows that inefficiency effects are present in the model, implying variation in output among betel nut growers in the Nagaon district. The estimated gamma (γ) is found to be 0.75, which implies that 75 per cent of the total variation in output is due to technical inefficiency, and 25 per cent variation is due to random variability. The mean technical efficiency of the betel nut growers was estimated to be 0.85. The negative technical inefficiency of betel nut growers has a positive effect on their technical efficiency. Thus, the negative signs in the inefficiency model show that family size, farming experience, and gender positively affect output. On the other hand, the positive signs of age and education of the grower variable indicate a negative effect on output. However, the family size and education of the respondents were not statistically significant, which is supported by the study conducted by Adesina and Djato (1996) and contradicts the findings of Aye and Mungatana (2010).

Experience and age of the grower: both variables are significant at the 1 per cent level. With increased experience, growers' productivity increases. This is because growers with many years of experience in betel nut cultivation increase their managerial ability to make optimal and efficient use of their limited resources, and, therefore, are more likely to have higher outputs and, consequently, more technically efficient. This result is consistent with that of Isaac (2011) and Abdulai (2013).

However, with increasing age of betel nut growers, the production of betel nuts decreases. A possible reason may be that with an increase in age, they may not have enough desire to maintain their betel nut orchard. This can adversely affect the technical efficiency of betel nut production. This result is consistent with Bonabana (2002), Essilfie (2011), and Addai and Owusu (2014), who found that older farmers could adversely affect their technical efficiency levels.

Gender, on the other hand, was statistically significant at the 5 percent level. If growers are male, productivity is higher than that of their female counterparts. A possible reason for this may be that females are physically weaker than males, whereas physical strength is required in betel nut cultivation. Moreover, females play a crucial role in household activities. Thus, this study found that male growers were technically more efficient than females.

Table 3. MLE of the parameters of Stochastic Frontier C-D Production Function.

Variables	Beta Coefficient	t-Statistic
Frontier Production Function		
Constant	3.323***	15.39
LAB (mandays/hectare)	0.626***	1.140

BPLANT (numbers of tree planted/hectare)	1.129***	11.62
AREA (hectare)	0.111*	2.331
Inefficiency Model		
Constant	0.0047	1.74
FAMSIZE (numbers)	-0.002	-0.0095
BEXP (years)	-0.025***	-4.023
EDU (years)	0.007	0.067
AGE (years)	0.008***	3.66
GENDER (1=male, 0=female)	-0.001**	-1.543
Sigma Squared (σ^2)	0.039***	10.95
Gamma (γ)	0.753***	9.87
LR	13.9***	
Mean Efficiency	0.85	
N	240	

Note: ***= significant at the 1% level, **= significant at the 5% level, and *= significant at the 10% level.

Output elasticity and returns to scale are also calculated to determine how efficiently the inputs are used, and whether returns to scale are increasing or decreasing. From Table 4, it appears that the estimated values of output elasticities for all inputs are positive. The elasticity of planted betel nut trees was 1.129. This may be because betel nut production increases with new plantations. Older betel nut trees may not be produced, as expected. Only mature betel nut trees were produced at the highest levels. Labor is also a significant factor with an elasticity of 0.626 but is subject to decreasing returns. This may be because betel nut growers are mostly aged. With an increase in people's age, their willingness to work declines. There were diminishing returns to the variable area, with an elasticity of 0.111. An increase in the area under betel nut cultivation is not always beneficial, as it may become unmanageable with household labor only. In Assam, betel nuts are not fully cultivated on a commercial basis; rather, they are cultivated to supplement income and meet household demands. Recently, betel nuts have been cultivated for commercial purposes, but using the most traditional method. However, we noticed that the total output elasticity is 1.866, which suggests increasing returns to scale. More specifically, if the growers increased all inputs by 1 per cent, it will increase the betel nut production by 1.8 per cent.

Table 4. Estimation of output elasticities.

SL No	Input Variable	Elasticity
1	Betel Nut Tree Planted	1.129***
2	Labour	0.626***
3	Area	0.111*
Total Output Elasticity		1.866

Note: ***= significant at the 1% level, **= significant at the 5% level, and *= significant at the 10% level.

7. Estimation of the Efficiency Score and Mean Technical Efficiency of the Betel Nut Growers

The mean technical efficiency of the betel nut growers was 85%, ranging from 68 per cent to 100 per cent. The frequency distribution of betel nut growers, based on their technical efficiency, is shown in Figure 1.

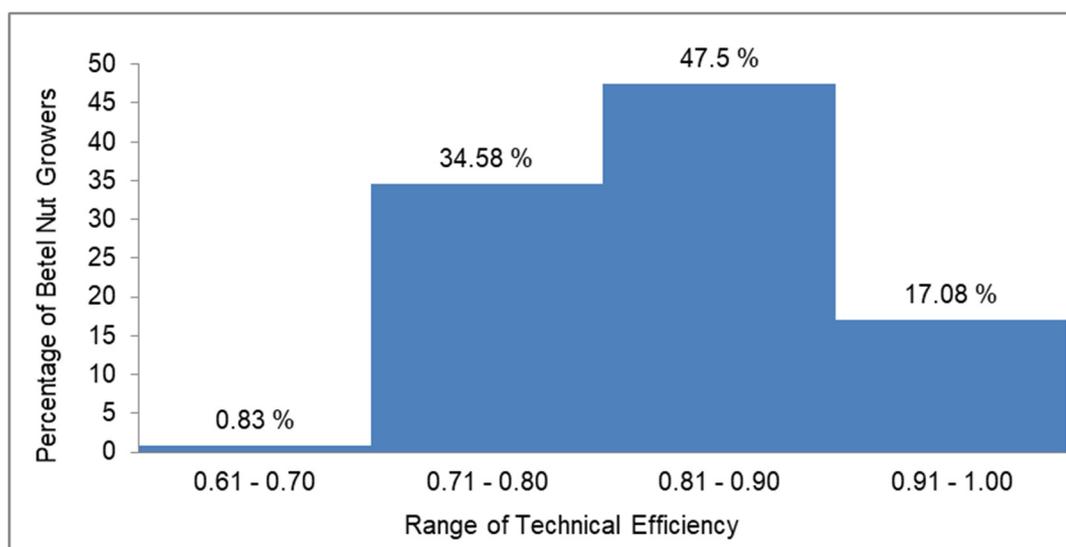


Figure 1. Frequency distribution of betel nut growers based on their technical efficiency levels.

Figure 1 reveals that 0.83 per cent of the growers had technical efficiencies in the range 0.61 to 0.70. Between 0.71 to 0.80, 34.58 per cent of betel nut growers produced betel nuts. However, 47.5% of growers produced in the range of 0.81 and 0.90. Finally, 17.08 per cent of growers produced betel nuts at an efficiency level 0.91 of 100. Among the 240 betel nut growers, the technical efficiency of 35.41 per cent of the betel nut growers was less than 80 per cent. On the other hand, 64.59 per cent of the growers produced betel nuts at an efficiency range above 0.80. Thus, there is scope to increase the productivity of betel nut growers in Nagaon district by increasing their technical efficiency.

8. Conclusion and Policy Recommendations

This study focuses on technical efficiency and the factors affecting technical efficiency among betel nut growers in the Nagaon district of Assam, India. It appears from this study that the mean efficiency score was 85%, indicating a potential loss of output due to inefficiency. This study further reveals that an optimum level of output efficiency can be attained using existing inputs.

From the results of the technical inefficiency model, it is evident that experience plays a major role in betel nut cultivation. Moreover, empowering females can also increase efficiency among growers. The government should adopt appropriate policies to encourage women to grow betel nuts, and provide incentives. Age is another significant factor determining inefficiency. With the increase in the age of betel nut cultivators, production falls; therefore, youth should be encouraged to cultivate betel nuts to generate income. In fact, information about the scope of betel nut cultivation as a source of self-employment should be disseminated among rural youths. Moreover, during the field survey, it was found that betel nut growers did not use chemical or organic fertilizers. If fertilizers are used for the cultivation of betel nuts, perhaps more production is possible, and there are more returns to betel nut cultivation. It was also found that the role of agricultural extension workers was insufficient to address the issues of betel nut growers. There is tremendous scope for increasing the efficiency of growers to raise the productivity of betel nuts in Assam. From this study, it appears that without the use of pesticides, fertilizers, mulching, and irrigation, the returns to scale were estimated at 1.866. Thus, if betel nut cultivation can be modernized, it is clear that the betel nut of Assam is an important commercial crop for the state, given its climatic and soil conditions.

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Ethical Compliance: All procedures performed in this study involving human participants were in accordance with the ethical standards of the Dibrugarh University Ethics Policy.

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