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Analysis of agro-climatic influences on pineapple cultivation in Nagaland

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Abstract

Pineapple is an important horticultural crop of Nagaland. The state's agro-climatic conditions contribute to its growth, making it an important part of the horticultural industry. The impact of agro-climatic factors on pineapple production was investigated using the multiple linear regression in this study. The evaluation of pineapple production data was based on time-series data from the Economic Survey of Nagaland and NASA POWER gridded climate datasets. The robustness of the regression is due to its 0.897 multiple correlation coefficient (R) and its R^2 coefficient of determination, which is 0.805. High values for R and R^2 respectively demonstrate a robust goodness of fit regression, which also fulfils crucial diagnostic criteria. Agricultural land area was the only factor that had a significant impact on pineapple fruit production. Heavy rainfall and strong winds can affect the yield of pineapples, but not always at the maximum rate. In addition, temperature and relative humidity positively influence production. In Nagaland, climate-resistant agriculture is crucial for pineapple production, as temperature and humidity affect yield while wind speed and rainfall have an adverse effect.

Keywords: Pineapple production, Agro-climatic factors, multiple linear regression, rainfall, temperature, climate variability

Introduction

Pineapple (*Ananas comosus*) is an important tropical fruit crop with significant nutritional and economic value, widely cultivated in humid and high rainfall regions. India is one of the leading producers of pineapple globally, with the northeastern region contributing more than half of the country's total production due to its favourable agro-climatic conditions. Among these states, Nagaland has emerged as a key pineapple-producing region, supported by its humid subtropical climate, abundant rainfall, and rich biodiversity (Hikal *et al.*, 2021), National Horticulture Board, 2023; Department of Horticulture Nagaland, 2022) ^[1, 2, 3].

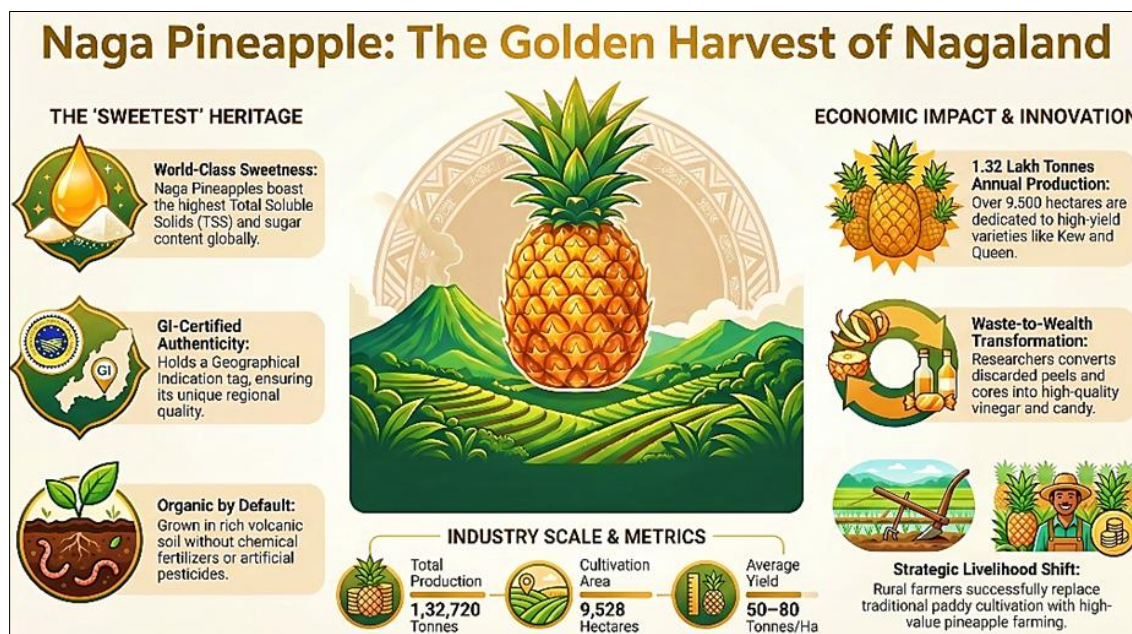
Pineapple cultivation plays a crucial role in the livelihood of farmers in Nagaland and contributes significantly to the state's horticultural economy. The crop is predominantly grown under traditional and organic farming systems, which enhance fruit quality and market demand (Kumar *et al.*, 2024) ^[4]. However, despite favourable conditions, productivity remains inconsistent due to variations in climatic and environmental factors. Recent studies highlight that pineapple cultivation in Nagaland is increasingly influenced by changing climatic conditions, necessitating the adoption of sustainable and climate-resilient practices.

Agro-climatic variables such as rainfall, temperature, relative humidity, and rainfall are critical determinants of crop growth, development, and yield. Pineapple is particularly sensitive to climatic variability, as it requires well-distributed rainfall and optimal temperature conditions for flowering and fruiting. Empirical evidence from northeastern India indicates that rainfall and soil conditions significantly influence pineapple productivity, with deviations leading to yield fluctuations. Similarly, studies in comparable agro-ecological regions have shown that climatic variability and extreme events can substantially affect horticultural production, including pineapple (FAO, 2021) ^[5].

Moreover, climatic factors, recent research highlights the significant role of socio-economic and technological determinants in shaping pineapple production systems. Studies from the northeastern region indicate that access to information, adoption of improved practices, and

farmer characteristics strongly influence production efficiency and sustainability. However, agro-climatic factors continue to be the primary drivers of yield variability, particularly in rainfed and hill-based agricultural systems such as those in Nagaland. Despite the importance of pineapple cultivation in Nagaland, there is a lack of comprehensive quantitative studies that simultaneously examine the effects of multiple agro-climatic variables on production. Most existing studies focus either on socio-economic aspects or isolated climatic factors, leaving a research gap in integrated climate–production analysis. Statistical approaches

such as Multiple Linear Regression (MLR) provide a robust framework for analyzing the combined influence of multiple climatic variables on crop yield (Pongener S. *et al.*, (2024))^[6]. Therefore, this study aims to investigate the agro-climatic determinants of pineapple production in Nagaland using a Multiple Linear Regression approach. The study seeks to quantify the relationship between key climatic variables and pineapple production, thereby providing insights for improving productivity and developing climate-resilient agricultural strategies in the region (Williams *et al.*, 2017)^[7].



Objective

The study is focus on examining the agro-climatic factors of pineapple production in the state of Nagaland using Multiple Linear Regression (MLR) approach. Pineapple, being a climate-sensitive horticultural crop, responds significantly to variations in temperature, rainfall, and humidity. Awareness of these relationships is essential for improving productivity under changing climatic conditions.

Specifically, the study seeks to examine the relationship between pineapple production and key agro-climatic variables such as temperature, rainfall, relative humidity, wind speed, and area. By applying a regression-based framework, the study aims to identify the most influential climatic factors affecting pineapple yield and assess their relative contributions.

Furthermore, the analysis intends to evaluate the direction and magnitude of the impact of each variable, thereby providing a scientific basis for interpreting how climatic variability influences production trends over time. The findings are expected to support evidence-based decision-making for farmers, researchers, and policymakers.

Ultimately, the study contributes to the development of climate-resilient agricultural strategies, improved crop management practices, and optimized resource utilization, which are crucial for enhancing pineapple productivity and ensuring the sustainability of the horticultural sector in the region.

Area of Study

This study focuses on the climate and favourable surroundings of Nagaland, an Indian state in the northeastern part of India that is well-suited for growing pineapple. Geographically, it is situated at a latitude of 25.17° N and 27.00° N latitude and from 93.15° E

to 95.15° E longitude, as per the Survey of India and the Government of Nagaland. It is located in the Indo-Myanmar hill ranges, the state is predominantly mountainous and has considerable variation from one region to another. The state's climate is primarily humid subtropical, with abundant rainfall and high humidity levels. During monsoon season, rainfall between 1,800 mm and 2,500 (about 324 m) falls annually, with an impact on crop yield, productivity, and growth.

Using multiple linear regression models, the research investigates how pineapple production is affected by various agro-climatic factors such as land area, temperature, precipitation, humidity, and wind speed. In the regression models, these climatic parameters are explanatory variables that provide substantial information about how they affect pineapple productivity across the state. In this study, pineapple production is examined in relation to key agro-climatic variables, including area, temperature, rainfall, humidity, and wind speed, using a multiple linear regression framework. The spatial and temporal variability of these climatic parameters across the state provides a robust basis for analyzing their impact on pineapple productivity. The diversity in micro-agro-climatic zones across Nagaland allows for a comprehensive assessment of how climatic variability affects pineapple yield, making the region an ideal case study for agro-climatic modelling and regression analysis (Nagaland State Climate Change Portal, 2024)^[8].

Materials and methods

Data source and preparations

The time series secondary data spanning 18 years (2008–2025) was utilized investigation to analyze the relationship between agro-climatic variables and pineapple production in Nagaland.

The production data were collected from department of Economic and Statistics, Government of Nagaland reports and statistical records, while the climatic variables were obtained from the NASA POWER database.

NASA POWER gridded climate data is a globally recognized data source that provides meteorological and solar energy parameters, derived from a combination of satellite observations, assimilation models, and reanalysis datasets. It offers reliable and consistent long-term climate data, particularly useful for agro-climatic and environmental studies in data-scarce regions.

The climatic variables considered in this study included temperature, rainfall (precipitation), relative humidity, and wind speed. These variables were selected based on their known influence on pineapple growth and productivity. The data were extracted for the specific geographic coordinates of the study area to ensure spatial relevance. Prior to analysis, the dataset underwent several pre-processing steps. Missing values, if any, were checked and handled appropriately to maintain data continuity. All variables were examined for consistency, and units were standardized where necessary. The time-series data were then organized in a structured format suitable for regression analysis. Additionally, exploratory analysis was performed to identify trends, variability, and potential anomalies in the dataset.

Software and diagnostic validation

Statistical analyses were carried out using IBM SPSS Statistics, which provides a robust environment for regression modelling and diagnostic checking. The Multiple Linear Regression (MLR) model was employed to examine the relationship between pineapple production and selected agro-climatic variables.

The model outputs included regression coefficient estimates, standard errors, t-statistics, and p-values to assess the statistical significance and individual contribution of each explanatory variable. Measures of model fit such as the multiple correlation coefficient (R), coefficient of determination (R^2), and adjusted R^2 were used to evaluate the explanatory power and overall performance of the model. Additionally, the ANOVA (Analysis of Variance) table was examined to test the overall significance of the regression model.

To ensure the validity and reliability of the results, several diagnostic checks were performed. Multicollinearity among independent variables was assessed using the Variance Inflation Factor (VIF) and tolerance values. The assumption of normality of residuals was evaluated through histogram and normality of residuals by normal probability (P-P) plots. Homoscedasticity (constant variance of errors) and linearity were verified using scatterplots of standardized residuals against predicted values. Furthermore, multicollinearity is tested using the Durbin-Watson statistic. These diagnostic procedures ensured that the underlying assumptions of regression were satisfied, thereby enhancing the robustness and credibility of the model results. Analyses were conducted in SPSS 29. Model outputs included coefficient estimates, standard errors, t-statistics, p-values, R, R^2 , adjusted R^2 , ANOVA table, and diagnostic statistics.

Model specification

The study employs multiple linear regression model. The multiple linear regression models are of the form

$$\tilde{Y} = \tilde{X} \tilde{\theta} + \tilde{\varepsilon} \dots\dots\dots (1)$$

In general, $\tilde{Y} = (Y_1, Y_2, \dots, Y_I, \dots, Y_N)$, an $n \times 1$ vector of observations,

$\tilde{X} = (X_{ij})_{n \times p}$, i.e., $n \times p$ matrix of coefficients,

$\tilde{\theta} = (\theta_1, \theta_2, \dots, \theta_i, \dots, \theta_p)$, i.e., a $p \times 1$ vector of parameters, and

$\tilde{\varepsilon} = (\varepsilon_1, \varepsilon_2, \dots, \varepsilon_i, \dots, \varepsilon_n)$; i.e., an $n \times 1$ vector of random errors, which

follows normal distribution with $E(\tilde{\varepsilon}) = 0$ and $V(\tilde{\varepsilon}) = \sigma^2 I_n$, I_n is the $n \times n$ identity matrix.

The statistical model developed for the production is defined as

$$Y_i = C \prod_{j=1}^p X_{ij}^{a_{ij}} e^{\varepsilon_i} \dots\dots\dots (2)$$

Where, $i = 1, 2, \dots, n$;

$j = 1, 2, \dots, p$

By taking logarithm, the above equation may equivalently given as

$$\log_e Y_i = b_{i0} + \sum_{j=1}^p b_{ij} \log_e X_{ij} + \varepsilon_i; \dots\dots\dots (3)$$

Where,

$i = 1, 2, \dots, 18$;

$j = 1, 2, \dots, 5$

Where,

Y_i = production of rice in the i^{th} year (tonne)

X_{i1} = pineapple cultivated area in the i^{th} year (hectares)

X_{i2} = temperature in the i^{th} year (degree Celsius)

X_{i3} = rainfall in the i^{th} year (in mm)

X_{i4} = specific Humidity in the i^{th} year at 2 meters (g/kg)

X_{i5} = windspeed at 10 meters (m/s)

Estimation and hypothesis testing

The regression coefficients were estimated using the Ordinary Least Squares (OLS) technique, and the statistical significance of the overall model was tested through ANOVA.

The null hypothesis for this analysis is:

$$H_0: \theta_{i1} = \theta_{i2} = \dots = \theta_{ip} = 0, i = 1, 2, \dots, n$$

The null hypothesis is tested using the Analysis of Variance (ANOVA) method.

Diagnostic tests and validation

To validate OLS assumptions and ensure inference reliability, comprehensive diagnostics were performed:

- Identifying outliers.
- Checking the identicalness or homogeneity of residual variance.
- Verifying the independence and normality of residuals.
- Assessing multicollinearity or the independence of random variables.
- Verifying whether the data were sampled from a normal population.

Results and Discussion

Statistical findings and agro-climatic insights

Table 1: Regression results

Model		Unstandardized Coefficients		t	Sig.	Collinearity Statistics	
		B	Std. Error			Tolerance	VIF
1	(Constant)	-4.033	3.659	-1.102	0.292		
	Logtemp	3.495	3.551	0.984	0.344	0.355	2.821
	Logwind	-1.556	1.281	-1.214	0.248	0.748	1.337
	Loghumidity	2.426	2.535	0.957	0.357	0.283	3.534
	Logarea	0.608	0.176	3.446	0.005	0.469	2.134
	Lograin	-0.149	0.225	-0.662	0.520	0.593	1.687

The regression results revealed that temperature, humidity, and area under cultivation had positive relationships with pineapple production, while wind speed and rainfall showed negative relationships (Table 1). Among all variables, only area under cultivation was statistically significant ($B = 0.608$, $p = 0.005$), indicating that a 1% increase in cultivated area increases

pineapple production by approximately 0.608%. Although temperature ($B = 3.495$), humidity ($B = 2.426$), wind speed ($B = -1.556$), and rainfall ($B = -0.149$) influenced production in different directions, their effects were statistically non-significant ($p > 0.05$), suggesting limited impact within the model.

Table 2: Model Summary^b

Model Summary ^b										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.897 ^a	.805	.724	.06087	.805	9.906	5	12	.001	1.776
a. Predictors: (Constant), Lograin, Logarea, Logwind, Logtemp, Loghumidity										
b. Dependent Variable: Logproduction										

From the table 2, regression model demonstrates a strong fit, with a multiple correlation coefficient (R) of 0.897 and an R^2 value of 0.805, indicating that 80.5% of the variation in pineapple production is explained by the selected agro-climatic variables.

The adjusted R^2 (0.724) confirms the model's robustness. The overall model is statistically significant ($F = 9.906$, $p < 0.01$), and the Durbin-Watson statistic (1.776) indicates no serious autocorrelation in the residuals.

Table 3: ANOVA

ANOVA ^a						
Model	Sum of Squares	df	Mean Square	F	Sig.	
1						
Regression	.183	5	.037	9.906	.001 ^b	
Residual	.044	12	.004			
Total	.228	17				
a. Dependent Variable: Logproduction						
b. Predictors: (Constant), Lograin, Logarea, Logwind, Logtemp, Loghumidity						

The ANOVA results (Table 3) indicate that the regression model is highly significant ($F = 9.906$, $p < 0.01$), demonstrating that the selected agro-climatic variables collectively explain a substantial proportion of the variation in pineapple production. The relatively

high regression sum of squares (0.183) compared to the residual sum of squares (0.044) further confirms the good fit of the model.

Regression diagnostics

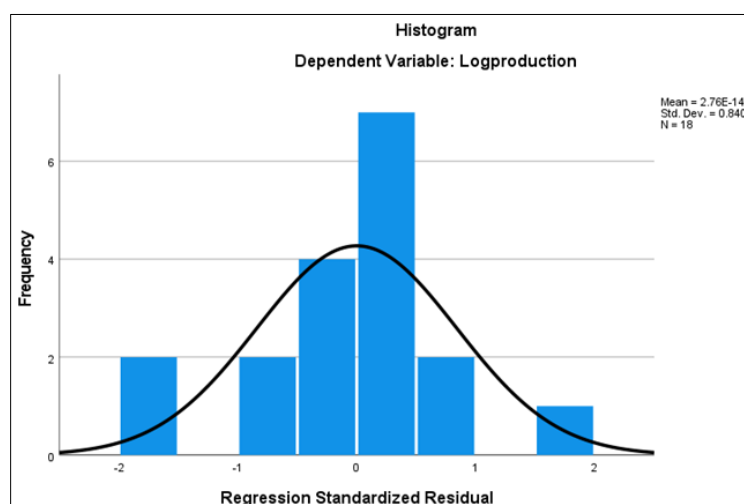


Fig 1: Histogram

The histogram (Fig. 1) of regression standardized residuals for the dependent variable *Logproduction* appears approximately bell-shaped and centered around zero, indicating that the residuals are fairly normally distributed. Most residual values are clustered near the centre, with only a few observations at the extreme ends. The mean residual is very close to zero (Mean = 2.72E-14) and

the standard deviation is close to 1 (Std. Dev. = 0.840), which suggests that the regression model satisfies the normality assumption reasonably well. Therefore, the residual distribution does not show serious deviation from normality, indicating that the regression results are likely reliable

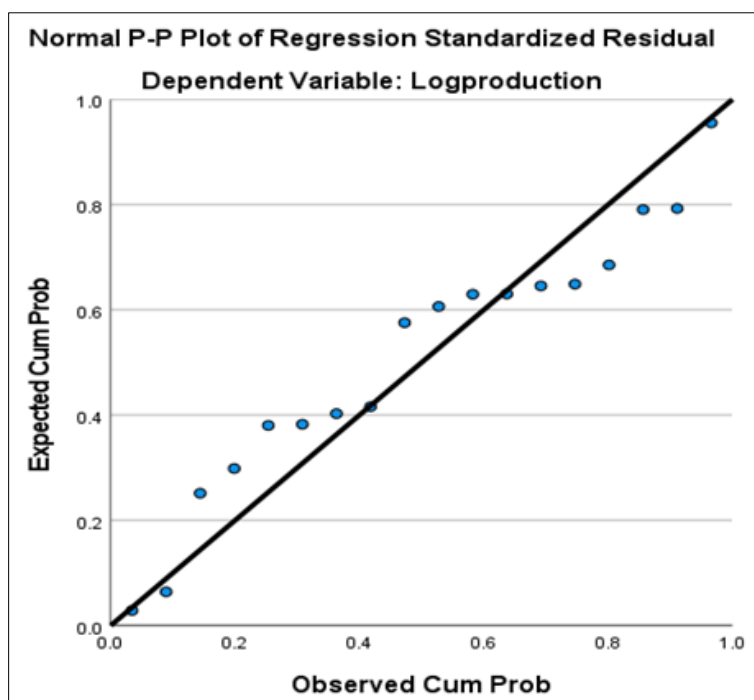


Fig 2: Normal pp plot

The Normal P-P Plot from Fig. 2, Regression Standardized Residuals, shows that most of the points lie close to the diagonal reference line. This indicates that the residuals are approximately normally distributed and the normality assumption of the

regression model is reasonably satisfied. Therefore, the regression model appears to fit the data adequately and the results can be considered reliable.

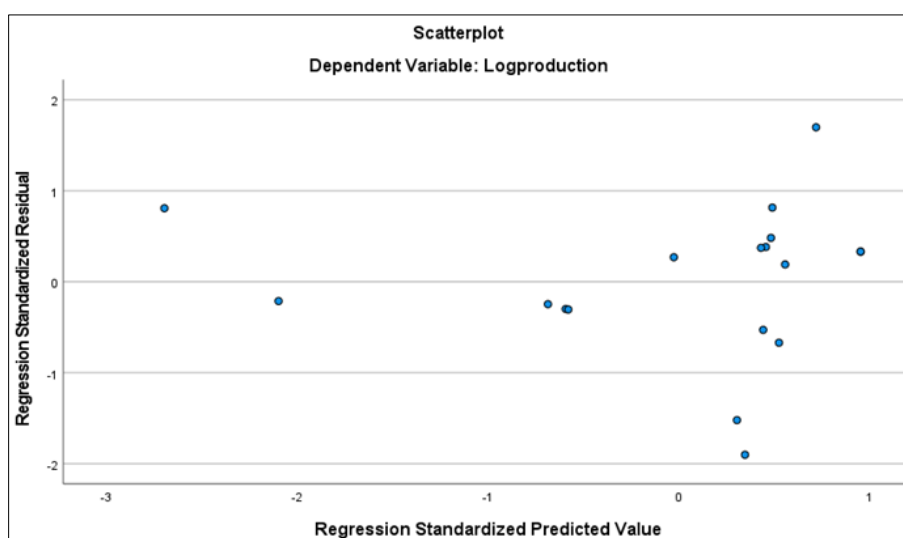


Fig 3: Scatter plot

From the Fig.3, the scatterplot of regression standardized residuals versus standardized predicted values, shows that the residuals are randomly scattered around zero without forming any clear pattern. This suggests that the assumptions of linearity and homoscedasticity (constant variance of errors) are reasonably satisfied in the regression model. Therefore, the regression model appears to provide an acceptable fit for explaining pineapple

production.

Conclusion

The study revealed that climatic and environmental factors play a significant role in influencing pineapple production in the state. The regression analysis showed that rainfall, cultivated area, temperature, humidity, and wind collectively exert a significant

effect on pineapple production. ANOVA results showed that the overall regression model was statistically significant, indicating that the selected agro-climatic variables are important determinants of production variability.

The state possesses favourable agro-climatic conditions for pineapple cultivation due to its suitable rainfall pattern, humid climate, and moderate temperature. However, variations in climatic parameters may directly affect productivity and yield stability. The findings suggest that proper management of climatic risks, efficient utilization of land, and adoption of climate-resilient agricultural practices can enhance pineapple production in the region.

The study further emphasizes the importance of scientific planning, improved cultivation practices, and policy support for sustainable pineapple production. Strengthening research, irrigation facilities, and farmer awareness programs can help maximize productivity and improve the economic condition of pineapple growers in the state, Nagaland. Overall, the research highlights that agro-climatic factors are crucial in determining pineapple production and should be carefully considered in future agricultural development strategies in Nagaland.

The recommended multiple linear regression model for pineapple production is:

$$\text{Log (Production)} = -4.033 + 3.495 \cdot \text{Log (temp)} - 1.556 \cdot \text{Log (wind)} + 2.426 \cdot \text{Log (humidity)} + 0.608 \cdot \text{Log (area)} - 0.149 \cdot \text{Log (rain)}$$

References

1. Hikal W, Mahmoud A, Said-Al Ahl H, Bratovcic A, Tkachenko K, Kačániová M *et al.* Pineapple (*Ananas comosus* L. Merr.), waste streams, characterisation and valorisation: An overview. *Open J Ecol* 2021;11:610-634.
2. National Horticulture Board. Indian Horticulture Database 2023. Ministry of Agriculture and Farmers Welfare, Government of India, 2023.
3. Department of Horticulture Nagaland. Annual Report 2021-2022. Government of Nagaland, 2022.
4. Kumar JS, Konyak WC. Enhancing horticulture and floriculture farming in Nagaland: Schemes and implementations. *Int J Agric Innov Res* 2024;12(5):190-204.
5. Food and Agriculture Organization. The State of Food and Agriculture 2021: Making Agrifood Systems More Resilient to Shocks and Stresses. FAO, 2021.
6. Pongener S, Jha KK. Information sources utilization and adoption behaviour of pineapple growers in Nagaland. *Indian J Ext Educ* 2024;60(1):46-52.
7. Williams PA, Crespo O, Abu M, Simpson NP. Impact of climate variability on pineapple production in Ghana. *Agric Food Secur* 2017;6:26.
8. Nagaland State Climate Change Portal. Nagaland State Climate Change Portal. Government of Nagaland, 2024