



## Adoption and Determinants of Sustainable Agricultural Practices (SAPs) among Pineapple Growers in Nagaland

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### HIGHLIGHTS

- Post-harvest management showed highest adoption across the three districts.
- Significant inter-district differences in SAP adoption were observed.
- “Land use and Income” factor accounted as the major determinant of SAP adoption.

### ARTICLE INFO

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### ABSTRACT

The study assessed the extent and determinants of adoption of sustainable agricultural practices (SAPs) among pineapple growers in Dimapur, Peren and Mokokchung districts of Nagaland during 2022-2023. A total of 275 respondents were selected using proportionate random sampling. Adoption was assessed using an adoption index covering agronomic practices, resource management, pest and disease management and post-harvest management. Inter-district differences were analysed using z-test and determinants were identified through factor analysis. Results revealed that majority (64.73%) of the respondents had medium level of adoption. Post-harvest management recorded the highest adoption, whereas resource management practices showed comparatively lower adoption. Significant differences in adoption indices were observed among the districts ( $p < 0.01$ ), with Mokokchung recording the highest mean adoption index (57.56). Factor analysis extracted eight components explaining 62.49 per cent of the total variance, with “land use and income” emerging as the major determinant, followed by motivational factors and extension access. The study highlights the need for location-specific extension strategies, strengthened institutional support and capacity building interventions to enhance sustainable pineapple cultivation in Nagaland.

### INTRODUCTION

Pineapple (*Ananas comosus*) is an economically important horticultural crop in Nagaland. The state's diverse and favourable agro-climatic conditions enable its cultivation across all the districts. According to the Directorate of Economics and Statistics (2025), pineapple was cultivated in an area of 9,053.12 hectares with a total production of 1,23,285.78 metric tons in Nagaland during 2023-24, with Dimapur leading in production (38,004 metric tons). Pineapple cultivation in the state is largely based on traditional and

low input production systems, providing scope for sustainable agricultural practices (SAPs) to enhance productivity and sustainability of resources.

Sustainable agricultural practices such as improved agronomic management, integrated nutrient management, integrated pest management and post-harvest handling play a crucial role in maintaining soil health, reducing environmental risks and improving farm profitability. However, the adoption of such practices varies depending on farmers' socio-economic characteristics, psychological attributes and access to institutional support (Priya & Singh, 2022;

Kumar et al., 2023; Bhujel & Joshi, 2024). Previous studies have reported that factors such as landholding size, income, education, extension contact and training exposure significantly influence adoption behaviour (Meena et al., 2023; Thangjam et al., 2024).

Although pineapple is widely cultivated in Nagaland, it is evident that the extent of adoption of sustainable practices and the determinants influencing adoption among pineapple growers remains limited. Understanding these aspects is essential for facilitating effective research, extension and policy interventions. Therefore, the present study was undertaken to assess the extent of adoption of sustainable agricultural practices among pineapple growers and identify the determinants influencing adoption of sustainable pineapple cultivation practices.

## METHODOLOGY

The study was conducted in three major pineapple growing districts of Nagaland; Dimapur, Peren and Mokokchung, purposively selected based on their area and production under pineapple with data collection during 2022-23. Four Rural Development (RD) Blocks were selected; Medziphema and Changtongya from Dimapur and Mokokchung districts and Peren and Jalukie from Peren district. Thirteen villages were selected from the RD Blocks based on the extent of pineapple cultivation. Under Dimapur, the villages of Molvom, Bungsang and Medziphema were selected; from Peren, the villages of Samzuiram, Mhainamtsi, Kejanglwa, Jalukie, Punglwa and Heningkunglwa; and from Mokokchung, Changtongya, Nukshiyim, Liroyim, and Yaongyimsen villages were selected. A proportionate random sampling method was followed, wherein 45 per cent of the total pineapple growers from the selected villages were included, resulting in a final sample size of 275 respondents.

Primary data were collected through a pre-tested interview schedule. The study assessed the adoption of sustainable agricultural practices among pineapple growers, grouped under four

major dimensions: agronomic practices, resource management (soil, water and nutrients), pest and disease management and post-harvest management. An adoption index was developed to quantify the level of adoption. Scores of '2', '1' and '0' were assigned for full, partial and non-adoption, respectively. Based on the cumulative adoption scores, respondents were classified into three categories; low, medium and high adoption. A z-test was used to compare the adoption levels among the three districts.

To identify the determinants influencing the adoption of sustainable agricultural practices, Principal Component Analysis (PCA) method was applied. Components with eigenvalues  $\geq 1$  were retained. Variables with factor loadings  $\geq 0.40$  were retained for interpretation. Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were applied to assess sampling adequacy.

## RESULTS

Table 1 revealed the adoption index of sustainable pineapple cultivation practices across the selected districts. Under agronomic practices, full adoption of propagation (100.00%) was observed in all districts. Moderate adoption was recorded for land preparation and spacing, while nil (0.00%) adoption was observed for growth regulators and treatment of planting material in all districts. Under resource management practices, weed management showed 100.00 per cent adoption in all districts. Ratooning recorded adoption indices ranging from 80.36–87.50 per cent, whereas manuring, irrigation and cropping pattern exhibited low adoption indices. Under pest and disease management, biological method (0.00%) was not adopted in any district. Cultural methods showed very high adoption (94.05–97.78%), while physical methods were adopted moderately (36.19–52.78%) across the districts. Post-harvest management dimension had comparatively higher adoption among all the dimensions. 100.00 per cent adoption of post harvest management and storage was observed across districts. Whereas adoption of value addition practices ranged from 13.33–19.71%.

**Table 1.** Adoption Index of sustainable practices in pineapple cultivation among the selected districts

Dimensions of SAPs	Areas of Sustainable practices	Adoption Index (AI)			Overall AI
		Mokokchung	Dimapur	Peren	
Agronomic practices	Land preparation	62.5	54.00	54.64	55.09
	Varieties	58.33	54.28	59.64	56.09
	Propagation	100.00	100.00	100.00	100.00
	Spacing	55.83	59.43	52.14	57.18
	Plant population	49.17	52.00	41.43	49.00
	Planting material	49.17	49.28	48.93	49.18
	Treatment of planting material	0.00	0.00	0.00	0.00
	Growth regulators	0.00	0.00	0.00	0.00
Resource management (Soil, water and nutrient)	Manuring	21.67	7.05	4.76	8.06
	Cropping pattern	49.17	19.14	15.00	21.36
	Ratooning	87.5	82.00	80.36	82.18
	Irrigation	13.33	11.43	8.57	10.91
	Mulching	65.55	49.62	43.81	49.88
	Weed management	100.00	100.00	100.00	100.00
Pest and disease management	Biological method	0.00	0.00	0.00	0.00
	Cultural method	97.78	95.52	94.05	95.39
	Physical method	52.78	42.67	36.19	42.12
Post-harvest management	Harvesting	99.44	93.52	94.05	94.30
	Storage	100.00	100.00	100.00	100.00
	Post-harvest management	100.00	100.00	100.00	100.00
	Value addition	13.33	19.71	15.36	17.91

Table 2 showed that majority of the respondents (64.73%) were found under the medium adoption category, followed by high (19.63%) and low (15.64%) categories. Mokokchung recorded the highest mean adoption index (57.56), followed by Dimapur (52.47) and Peren (50.28). Z-test revealed significant differences in adoption indices between Dimapur and Peren ( $z = 3.435$ ,  $p < 0.01$ ), Dimapur and Mokokchung ( $z = 5.845$ ,  $p < 0.01$ ) and Peren and Mokokchung ( $z = 7.334$ ,  $p < 0.01$ ).

Table 3 exhibited factors influencing the adoption of sustainable cultivation practices in pineapple. Factor analysis extracted eight factors with eigenvalues  $\geq 1$ , explaining 62.49 per cent of the total variance ( $KMO = 0.728$ ). Factor 1 (Land Use and Income) accounted for the highest variance (18.29%) and included variables, size of landholding under agriculture, land under pineapple cultivation, annual income, profitability, productivity and employment generated.

Factor 2 (Motivational Factor) explained 10.30 per cent of the variance and included innovativeness, risk-bearing ability, market innovativeness, achievement motivation and scientific orientation. Factor 3 (Extension Access) contributed 7.48 per cent of the variance and comprised information sources utilization, productivity, extension contact and training exposure. The remaining factors were management and market awareness (6.36%), socio-economic participation (5.71%) socio-economic (5.36%), nutrient management (4.68%) and resource use efficiency (4.31%).

## DISCUSSION

The adoption pattern observed in sustainable pineapple cultivation reflects farmers' preference for practices that are familiar, economically viable and compatible with existing farming systems. Practices that are simple, yield immediate benefits and low-risks

**Table 2.** District-wise Adoption Index and adoption level of sustainable pineapple cultivation practices

District	Low adoption (AI < 47.28)	Medium adoption (AI: 47.28 - 57.66)	High adoption (AI > 57.66)	Mean AI $\pm$ SD
Dimapur	26 (14.86)	115 (65.71)	34 (19.43)	52.47 $\pm$ 5.14 <sup>b</sup>
Peren	17 (24.29)	48 (68.57)	5 (7.14)	50.28 $\pm$ 4.26 <sup>c</sup>
Mokokchung	0 (0.00)	15 (50.00)	15 (50.00)	57.56 $\pm$ 3.86 <sup>a</sup>
Overall (275)	43 (15.64)	178 (64.73)	54 (19.63)	52.47 $\pm$ 5.19

Note: Values under Low, Medium and High adoption are frequency followed by percentage in parentheses. Means followed by different superscripts are significantly different at the 1 per cent level based on pairwise z-tests

**Table 3.** Rotated factor matrices of the variables along with factor loadings, variance and factors renamed

Factors	Variables	Factor loading	% of variance explained	Cumulative % explained
Factor -1 Land use and income	Size of landholding under agriculture ( $X_{13}$ )	0.851	18.293	18.293
	Size of land under pineapple cultivation ( $X_{14}$ )	0.915		
	Annual income ( $X_{15}$ )	0.676		
	Profitability ( $X_{16}$ )	0.652		
	Productivity ( $X_{17}$ )	0.437		
	Employment generated ( $X_{18}$ )	0.919		
Factor -2 Motivational factor	Innovativeness ( $X_8$ )	0.647	10.299	28.592
	Risk bearing ability ( $X_9$ )	0.489		
	Market innovativeness ( $X_{10}$ )	0.671		
	Achievement motivation ( $X_{12}$ )	0.750		
	Scientific orientation ( $X_{27}$ )	0.423		
Factor -3 Extension access	Sources of information utilization ( $X_7$ )	0.782	7.481	36.073
	Productivity ( $X_{17}$ )	0.435		
	Extension contact ( $X_{24}$ )	0.785		
	Training exposure ( $X_{25}$ )	0.425		
Factor -4 Management and market awareness	Education ( $X_4$ )	0.433	6.357	42.430
	Market orientation ( $X_{20}$ )	0.813		
	Management orientation ( $X_{21}$ )	0.772		
Factor -5 Socio-economic participation	Social participation ( $X_6$ )	0.503	5.707	48.138
	Decision making ability ( $X_{11}$ )	0.651		
	Economic motivation ( $X_{19}$ )	0.601		
Factor -6 Socio-economic	Age ( $X_1$ )	0.809	5.355	53.493
	Family size ( $X_2$ )	0.598		
	Experience ( $X_{26}$ )	0.693		
Factor -7 Nutrient management	Economic motivation ( $X_{19}$ )	0.435	4.681	58.174
	Integrated Nutrient Management ( $X_{23}$ )	0.664		
Factor -8 Resource use efficiency	Input self-sufficiency ( $X_3$ )	0.734	4.312	62.486
	IPM ( $X_{22}$ )	0.521		
	Scientific orientation ( $X_{27}$ )	0.519		
	Kaiser-Meyer-Olkin Measure	0.728		

tend to be more readily adopted, whereas technically demanding or input-intensive practices remain constraint by limited technical knowledge, input accessibility and perceived risks. Similar patterns were reported by Rizzo et al. (2024), Singh and Mazhar (2024) & Thangjam and Jha (2025) also reported low adoption of advanced agronomic and sustainable practices due to limited scientific guidance and training support. Mixed adoption of resource management dimension indicated resource related constraints. Labour requirements, cost and resource constraints, limited technical guidance and inadequate extension support may have probably led to low adoption of integrated management practices, as also observed in the study by Das et al. (2014) and Ekyaligonza et al. (2024). In pest and disease management, higher adoption of cultural and physical methods suggests farmers' inclination towards environmentally safe and low-cost practices. In contrast, zero adoption of biological method indicates gaps in awareness, training and access to effective bio-control agents (Russo et al., 2025). Very high adoption of post-harvest practices indicates familiarity with basic handling operations. The relatively limited engagement in value addition may be due to infrastructural, market linkage gaps and constraints in adopting value-added technologies as reported by Rai et al. (2023) and Kumar et al. (2025).

Significant variance in district-wise adoption analysis may be attributed to differences in resource base, exposure to extension services and institutional access. These findings underscore the need for enhancing adoption intensity across the districts through location-specific extension strategies.

Factor analysis revealed the multidimensional nature of adoption behaviour. The dominance of "land use and income" suggests that farmers with larger land holdings, higher income and profitability are more likely to adopt sustainable practices, emphasizing the role of economy capacity in technology adoption (Nadaf et al., 2025).

Notably, market orientation, extension contact and management orientation, which exhibited high factor loadings, are widely recognized as critical determinants of adoption behaviour. Farmers with stronger market orientation are better able to respond to market demand and price signals, thereby enhancing adoption of improved practices, particularly in emerging agricultural systems of Northeastern India where market linkages remain crucial (Das et al., 2015; Ghosal & Gangabhusan, 2024). Similarly, extension contact significantly influences adoption by improving access to information, training and technical support, as evidenced in studies on pineapple growers in Nagaland where information source utilization showed a strong positive association with adoption behaviour (Paramasivam et al., 2021; Pongener & Jha, 2024). In addition, higher management orientation enables farmers to plan resource use efficiently and make better production decisions, which has been identified as a key determinant of adoption of farm business and sustainable practices in Indian agriculture (Thakur et al., 2022). Furthermore, studies also highlight that variables such as training exposure, social participation and access to extension services significantly influence farmers' adoption behaviour and attitudes toward sustainable pineapple cultivation (Pongener & Jha, 2023 Kumar et al., 2025). These factors help explain the relatively higher adoption levels in Mokochung.

Farmers with higher education, stronger managerial ability and market orientation were also more likely to adopt sustainable practices, consistent with Iticha and Taresa (2020). The identification of nutrient management and resource use efficiency as distinct factors further highlights the need for integrated approaches such as Integrated Nutrient Management (INM) and Integrated Pest Management (IPM). Empirical evidence indicates that INM enhances nutrient use efficiency, productivity and soil health (Meena and Suman, 2025), while IPM practices such as trap cropping in pineapple reduce pest incidence (Abdullah et al., 2024). Strengthening training and input access in these areas can improve sustainability and adoption intensity.

## CONCLUSION

The study revealed uneven adoption of sustainable agricultural practices (SAPs) in pineapple cultivation across dimensions and districts. Post-harvest and agronomic practices showed relatively higher adoption compared to resource management practices, highlighting a need for targeted interventions in soil, water and nutrient management. Adoption behaviour was influenced by motivational attributes, economic factors and access to extension services, emphasizing the multidimensional nature of technology adoption. The inter-district variations in adoption further needs location-specific extension planning. Strengthening institutional support, improving extension services and capacity building particularly in promoting Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) are vital for enhancing sustainable pineapple cultivation in Nagaland.

## DECLARATIONS

**Ethics approval and informed consent:** Throughout the study, the respondents were asked for their informed consent.

**Conflict of interest:** The research was carried out without any financial or commercial ties that might be seen as a potential conflict of interest, according to the authors. The authors affirm that they carefully examined, amended and edited the content as necessary when preparing this work. The final content of this publication is entirely the authors' responsibility.

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