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RESEARCH PAPER

Agricultural Technology Adoption in Garo Hills, Meghalaya: An Adoption Index Analysis

Anuradha Seal[1*], Gino A Sangma[1], Vipin Arya[1], Trinadha Rao Bandaru[2] and Alisha[2]

[1]Department of Agri-Business Management and Food Technology, North-Eastern Hill University, Tura Campus, Tura, Meghalaya, India

[2]Department of Management, North-Eastern Hill University, Tura Campus, Tura, Meghalaya, India

*Corresponding author: anuradhaseal@gmail.com (**ORCID ID:** 0000-0002-0125-186X)

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ABSTRACT

Agriculture technology has the potential to improve both productivity and sustainability. The agriculture sector in Meghalaya's Garo Hills region heavily depends on traditional practices such as shifting cultivation also known as 'Jhumming" with minimal integration of modern agricultural technologies. This study aims to evaluate the adoption of improved agricultural practices among farmers in five districts of Garo Hills. A sample of 500 farmers was selected to assess their adoption of improved agricultural technologies. The respondents were classified as low, partial, or high adopters based on their score index. The results showed a strong tendency toward partial adoption, with 68.40% of farmers classified as partial adopters, 15.60% as low adopters and 16.00% as high adopters. The study found that demographic, socioeconomic and educational characteristics influence farmer technology adoption with gender, age, education, landholding size and income showing significant relationships.

HIGHLIGHTS

- Majority of respondents were partial adopters of agricultural technologies.
- Farmers with large landholdings and higher income showed significantly higher adoption levels.
- Education positively influenced adoption, however some illiterate farmers also adopted improved technologies.
- Gender had a statistically significant effect, female respondents were found to have higher adoption rates.

Keywords: Agricultural Technology, Adoption Index, Technology Adoption, Agricultural Development, Sustainable Agriculture

Agriculture in Meghalaya, particularly in the Garo Hills region, is predominantly traditional with practices such as 'Jhum" or shifting cultivation still common. Given the challenges global agriculture is facing and the projected increase in global population to over 9.6 billion people by 2050, there will be a sharp increase in the demand for food (UNDESA, 2017). Increasing agricultural productivity is essential to meet the rising demand for food whereas agricultural technology plays a critical role in increasing productivity (Udimal *et al*. 2017). The challenges associated with low crop yield and productivity can be overcome by the implementation of advanced farming technologies (Upendra *et al*. 2020). Therefore, it is necessary to understand the adoption of technologies among farmers. Against this background, the research was carried out with the aim of assessing the behaviour of farmers regarding the adoption of agricultural

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technologies within the Garo Hills region of Meghalaya.

Multiple studies have underscored the importance of adopting technologies in agriculture to overcome production constraints, increase productivity and achieve higher yields and food security. Despite efforts from governments and development organisations, the adoption of agricultural technology remains limited and low (Fayedi *et al*. 2022; Feyisa, 2020; Ruzzante *et al*. 2021). A complex interplay of factors influences technology adoption, that can be broadly classified as household-specific, economic, institutional and technology factors (Mwangi and Kariuki, 2015). These factors could contribute to or hinder the adoption process. Age, gender, and farming experience were found to have different influences in adoption decisions (Akudugu *et al*. 2023). In studies on agricultural technology adoption, household educational status also has been found as an important predictor. Higher education levels among farmers have a positive correlation with technology adoption, as they improve their ability to receive, analyze, and apply relavant information, boosting their likelihood of adopting new agricultural technologies (Mwangi and Kariuki, 2015).

METHODOLOGY

The current study was carried out in the Garo Hills region of Meghalaya. The region is divided into five districts namely, West Garo Hills, East Garo Hills, South Garo Hills, North Garo Hills and South West Garo Hills. The study used a multi-stage sampling technique across the five districts of Garo Hills, Meghalaya. In each district, seven major departments involved in extensive agricultural technology dissemination were purposively chosen. Farmers who have attended at least one training programme related to agricultural technology between the year 2017 and 2022 were identified using records from these departments. Using stratified random sampling, 100 farmers were selected from each district, for a total sample of 500 farmers. Primary Data was collected through personal interview method of selected respondents. A semi-structured data collection schedule was developed. The collected data was analyzed using various statistical measures such as percentage, frequency, mean etc. Both MS Excel and IBM SPSS software were used for data analysis.

Adoption Index

In the present study, adoption refers to the acceptance and implementation of some or all the improved production technologies in agriculture. The scope of our study is comprehensive, covering a wide range of technologies of both traditional and improved practices such as hydroponics, System of Rice Intensification (SRI) as well as Integrated Paddy cum Fish Culture; Artificial Insemination (AI) techniques, cross-breeding methods, improved management practices of dairy, cattle, piggery and goatery; mushroom production, Integrated Farming System and Sericulture, among others.

The adoption index was generated using 34 different agriculture technologies and practices. These indicators cover a wide range of modern farming techniques, including production technologies for various crops, improved cultivation practices, the use of high-yielding variety seeds, integrated farming systems, conservation agriculture practices (such as zero tillage and mulching), intercropping and mixed cropping strategies, organic farming practices, soil management techniques, water conservation methods, livestock management, post-harvest technologies, sericulture and specialized practices such as hydroponics. The overall adoption score of a respondent is calculated by summing up the scores for each practice. The level of adoption of agricultural technology among respondents was measured using Karthikeyan's (1994) adoption index, a method similar to that used in prior research (Kungumaselvan *et al*. 2020).

$$\text{Adoption Index} = \frac{\begin{array}{c}\text{Sum of the adoption}\\ \text{score of n items}\end{array}}{\begin{array}{c}\text{Maximum possible}\\ \text{adoption score}\end{array}} \times 100$$

Where n = number of items in the adoption scale

Based on the degree to which they adopted improved technologies, respondents were classified into three categories: (1) Low adopters (up to 33%) (2) Partial adopters (34-66%) and (3) High adopters (67-100%).

RESULTS AND DISCUSSION

Profile of Respondents

Table 1 gives a comprehensive overview of the socio-economic characteristics of the respondents, with males comprising 49.2% and females 50.8% of the sample.

The data revealed that the respondents' ages varied widely, with the largest percentage (40.2%) lying between the ages of 31-45 years, with a female majority of 23.8% compared to 16.4% males (Table 1). The 45-60 age group follows at 33%, with males and females comprising 16.4 % and 16.6 % respectively. Remarkably, the youngest age group (less than 30) had a significant gender disparity with 13.4% men and 7.6% females. In terms of education, the majority were literate, while only 8 % were illiterate, with 5.8% females versus 2.2% males. The largest group, representing 39.8% of respondents, had finished upper primary schooling (classes VI-VIII), with females (20.6%) and males (19.2%) reaching this educational level.

Adoption Level Distribution

The adoption level of agricultural technology among the respondents was measured through the adoption index. Table 2 shows the respondents' degrees of acceptance of improved agricultural technologies, classifying them into three groups according to their adoption score: low (up to 33%), partial (34-66%), and high (67-100%) adopters.

The data from Table 2 shows a strong tendency towards partial adoption, with 68.40% falling into the Partial Adopters category aligning with the observation by Kharjana *et al*. (2017) of a similar trend among ginger farmers in the *Ri-Bhoi* district of Meghalaya. In contrast to the present findings, Marak *et al*. (2015) reported that 35% of respondents were at a medium level of adoption. This indicates that more farmers have now started adopting these technologies in their farming practices. On the other hand, 15.60% were categorized as low adopters, highlighting a smaller portion of the population that minimally practices these technologies. The present finding is significantly lower than the 42% low adoption rate for pineapple production technology found by Marak *et al*. (2015). Furthermore, 16.00% of respondents were identified as high adopters, a slightly larger, yet limited proportion of respondents that have completely implemented improved agricultural technologies in their farming practices.

Table 1: Socio-economic characteristics of the respondents by Gender

Socio-economic Factor	Category	Male Count	Male %	Female Count	Female %	Total Count	Total %
Age	Less than 30	67	13.4%	38	7.6%	105	21.0%
	30-45	82	16.4%	119	23.8%	201	40.2%
	45-60	82	16.4%	83	16.6%	165	33.0%
	Above 60	15	3.0%	14	2.8%	29	5.8%
Education	Illiterate	11	2.2%	29	5.8%	40	8.0%
	Primary (Classes I-V)	92	18.4%	70	14.0%	162	32.4%
	Upper Primary (VI-VIII)	96	19.2%	103	20.6%	199	39.8%
	Secondary (IX-X)	33	6.6%	42	8.4%	75	15.0%
	Higher Secondary (XI-XII)	14	2.8%	10	2.0%	24	4.8%
Total		246	49.2%	254	50.8%	500	100.0%

Source: *Primary Data.*

Table 2: Overall adoption level of agricultural technologies by respondents

Adoption Level	Score Index	Frequency	Percentage
Low adopter	Up to 33%	78	15.60%
Partial adopter	34-66%	342	68.40%
High adopter	67-100%	80	16.00%
Grand Total		500	100.00%

Table 3 depicts that the technology adoption levels of females are slightly higher than males. The Chi-Square test for independence shows a significant association between gender and technology adoption, χ^2 (2, n = 500) = 7.076, p = .000, Cramer's V = .119). The Cramer's V (.119) indicates the association's effect size is small (Pallant, 2011:220).

Majority of the farmer respondents are in the age group of 30-60 years and possessing higher technology adoption levels than other age groups (Table 4). The Chi-Square test result supporting this phenomenon significantly, χ^2 (6, n = 500) = 51.496, p = .000. The age of the farmers has moderate effect with their technology adoption levels (Cramer's V = .119).

The farmer respondents' educational qualifications were grouped into five starting from illiterate to higher secondary and above (Table 5). The majority of respondents completed their primary and high school education. Along with the education level, adoption of technology has also increased. But a good number of illiterate group farmers also highly adopted technology. The observations of technology adoption and educational qualification have shown a significant association but the effect size is small. This indicates apart from education, some other factors are influencing farmers to adopt technology, χ^2 (8, n = 500) = 31.561, p = .000. Cramer's V = .178.

The size of total land held by the farmers has been categorised as marginal, small, medium, and large (Table 6). The cross tabulation for landholding size and technology adoption levels has shown that the majority of the farmers fall under the marginal category. The farmer's technology adoption levels have increased along with the increase in landholding size. The association between technology adoption and landholding size is significant with a large effect size, χ^2 (6, n = 500) = 225.438, p = .000. Cramer's V = .475.

The cross-tabulation for farmer respondents' landholding size and household monthly income (Table 7) depicted that the majority of the marginal landholding farmer's household income is below ₹ 15000/-. Along with the increase in landholding

Table 3: Distribution of Technology Adoption Levels by Gender

Gender		Low adopter	Partial adopter	High adopter	Total	Chi-Square and P-Value
Male	Frequency	37	180	29	246	Pearson Chi-Square value = 7.076 p = .029, df = 2 Cramer's V = .119
	Percentage	7.40%	36.00%	5.80%	49.20%	
Female	Frequency	41	162	51	254	
Percentage		8.20%	32.40%	10.20%	50.80%	
Total	Frequency	78	342	80	500	
	Percentage	15.60%	68.40%	16.00%	100.00%	

0 cells (0.0%) have expected count less than 5. The minimum expected count is 38.38.

Table 4: Distribution of Technology Adoption Levels by Age

Age		Low adopter	Partial adopter	High adopter	Total	Chi-Square and P-Value
Less than 30	Frequency	25	78	2	105	Pearson Chi-Square value = 51.496 p = .000, df = 6 Cramer's V = .227
	Percentage	5.00%	15.60%	0.40%	21.00%	
30-45	Frequency	40	137	24	201	
	Percentage	8.00%	27.40%	4.80%	40.20%	
45-60	Frequency	12	105	48	165	
	Percentage	2.40%	21.00%	9.60%	33.00%	
60 and above	Frequency	1	22	6	29	
	Percentage	0.20%	4.40%	1.20%	5.80%	
Total	Frequency	**78**	**342**	**80**	**500**	
	Percentage	**15.60%**	**68.40%**	**16.00%**	**100.00%**	

2 cells (16.7%) have expected count less than 5. The minimum expected count is 4.52.

Table 5: Distribution of Technology Adoption Levels by Educational qualifications

Educational Qualifications		Low adopter	Partial adopter	High adopter	Total	Chi-Square and P-Value
Illiterate	Frequency	1	27	12	40	
	Percentage	0.20%	5.40%	2.40%	8.00%	
Primary	Frequency	33	117	12	162	
	Percentage	6.60%	23.40%	2.40%	32.40%	
High School	Frequency	30	128	41	199	Pearson Chi-Square value = 31.561
	Percentage	6.00%	25.60%	8.20%	39.80%	
SSLC	Frequency	10	58	7	75	p = .000, df = 8
	Percentage	2.00%	11.60%	1.40%	15.00%	Cramer's V = .178
12th and above	Frequency	4	12	8	24	
	Percentage	0.80%	2.40%	1.60%	4.80%	
Total	Frequency	**78**	**342**	**80**	**500**	
	Percentage	**15.60%**	**68.40%**	**16.00%**	**100.00%**	

2 cells (13.3%) have expected count less than 5. The minimum expected count is 3.74.

Table 6: Distribution of Technology Adoption Levels by Landholding Size

Landholding size (in Hectare)		Adoption level				Chi-Square and P-Value
Low adopter		**Partial adopter**	**High adopter**	**Total**		
Marginal (below 1.0 ha)	Frequency	76	277	9	362	
	Percentage	15.2%	55.4%	1.8%	72.4%	
Small (1.0 – 2.0 ha)	Frequency	1	45	26	72	
	Percentage	0.2%	9.0%	5.2%	14.4%	Pearson Chi-Square value = 225.438
Medium (2.0 – 3.0 ha)	Frequency	1	20	33	54	
	Percentage	0.2%	4.0%	6.6%	10.8%	p = .000, df = 6
Large (above 3.0 ha)	Frequency	0	0	12	12	Cramer's V = .475
	Percentage	0.0%	0.0%	2.4%	2.4%	
Total	Frequency	**78**	**342**	**80**	**500**	
	Percentage	**15.6%**	**68.4%**	**16.0%**	**100.0%**	

2 cells (16.7%) have expected count less than 5. The minimum expected count is 1.87.

Table 7: Distribution of Respondents according to Landholding size and Household Monthly Income

Landholding size		Household Monthly Income					Chi-Square and P-Value
(in Hectare) Below 15000		**15000-30000**	**30000-45000**	**Above 45000**	**Total**		
Marginal (below 1.0 ha)	Frequency	248	93	18	3	362	
	Percentage	49.6%	18.6%	3.6%	0.6%	72.4%	
Small (1.01 – 2.0 ha)	Frequency	3	36	28	5	72	
	Percentage	0.6%	7.2%	5.6%	1.0%	14.4%	Pearson Chi-Square value = 225.438
Medium (2.01 – 3.0 ha)	Frequency	0	4	42	8	54	Likelihood Ratio = 332.460
	Percentage	0.0%	0.8%	8.4%	1.6%	10.8%	
Large (above 3.0 ha)	Frequency	0	1	4	7	12	p = .000, df = 9
	Percentage	0.0%	0.2%	0.8%	1.4%	2.4%	Cramer's V = .495
Total	Frequency	**251**	**134**	**92**	**23**	**500**	
	Percentage	**50.2%**	**26.8%**	**18.4%**	**4.6%**	**100.0%**	

5 cells (31.3%) have expected count less than 5. The minimum expected count is .55.

size, the farmer's household monthly income has increased. The Chi-Square Independence test result showed a significant association with a large effect size, χ^2 (9, n = 500) = 332.460, p = .000. Cramer's V = .495.

The cross tabulation of respondent's household monthly income and technology adoption levels shows that higher monthly income leads to high technology adoption levels (Table 8). The Chi-Square test result has shown a significant association with a large effect size. It indicates that households whose monthly income is higher are likely to adopt more agricultural technology. χ^2 (6, n = 500) = 202.676, p = .000. Cramer's V = .450.

Comparative analysis of technology adoption across the five districts

Table 9 presents a comparative analysis of technology adoption levels across five districts within the Garo Hills. It reveals variations in the adoption of agricultural technology, with all districts showing a higher percentage of partial adopters compared to low and high adopters.

From Table 9, it was observed that West Garo Hills district had the highest percentage of high adopters (5.40%), indicating a relatively higher engagement of extensive agricultural technology practices when compared to other districts. West Garo Hills also showed a balanced distribution among the three adoption categories, with 5.60% as low adopters, 9.00% as partial adopters and 5.40% as high adopters.

East Garo Hills district showed a slightly higher inclination towards partial adoption at 12.20%, with lower proportions of low and high adopters. Notably, South Garo Hills district had no low adopters and the highest percentage of partial adopters at 19.00%, yet it also had the lowest percentage of high adopters at 1.00%. It was observed that North Garo Hills district had the lowest percentage of low adopters at 2.40 %. South West Garo Hills district was found to have a higher

Table 8: Distribution of Technology Adoption Level by Household Monthly Income

Household monthly Income (₹)		**Adoption level**				**Chi-Square and P-Value**
Low adopter		**Partial adopter**	**High adopter**	**Total**		
Below 15000	Frequency	56	192	3	251	Pearson Chi-Square value = 202.676 p = .000, df = 6 Cramer's V = .450
	Percentage	11.2%	38.4%	0.6%	50.2%	
15000-30000	Frequency	20	100	14	134	
	Percentage	4.0%	20.0%	2.8%	26.8%	
30000-45000	Frequency	2	47	43	92	
	Percentage	0.4%	9.4%	8.6%	18.4%	
45000 and above	Frequency	0	3	20	23	
	Percentage	0.0%	0.6%	4.0%	4.6%	
Total	Frequency	**78**	**342**	**80**	**500**	
	Percentage	**15.6%**	**68.4%**	**16.0%**	**100.0%**	

2 cells (16.7%) have expected count less than 5. The minimum expected count is 3.59.

Table 9: Adoption Levels of Agricultural Technologies Across Districts in Garo Hills

District	**Low adopter**		**Partial adopter**		**High adopter**	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
West Garo Hills	28	5.60%	45	9.00%	27	5.40%
East Garo Hills	17	3.40%	61	12.20%	22	4.40%
North Garo Hills	12	2.40%	76	15.20%	12	2.40%
South Garo Hills	0	0.00%	95	19.00%	5	1.00%
South West Garo Hills	21	4.20%	65	13.00%	14	2.80%
Total	78	**15.60%**	342	**68.40%**	80	16.00%

percentage of partial adopters at 13.00%, although low and high adoption levels were closer to the overall trends observed in other districts.

CONCLUSION

The study revealed a strong tendency towards partial adoption of agricultural technologies in the Garo Hills region of Meghalaya. 68.40% of farmers were found to be partial adopters, while 15.60% were low adopters and 16.00% were high adopters. This suggests that while many farmers are open to trying new technologies, there are still barriers preventing full adoption.

The study also highlights the multidimensional nature of technology adoption in agriculture, which is influenced by a range of demographic, socioeconomic and educational factors. Gender showed a small but significant association with technology adoption, with females having slightly higher rates. Age had a moderate effect, with 30-45 and 45-60 years old showing higher adoption. This suggests that younger farmers are more likely to adopt improved technologies and adoption increases with age for younger farmers as they gain experience but decreases once they reach the age of retirement. Educational qualifications had a small significant effect, though some illiterate farmers also showed high adoption. Landholding size and household monthly income both showed strong associations with technology adoption, with larger landholdings and higher incomes correlating with greater adoption levels as more operational land holdings result in increased implementation of modern farming methods.

Recommendations

1. The government should provide targeted credit support programs or subsidies for marginal and small landholders and low-income farmers to encourage technology adoption.
2. Collective farming initiatives may be promoted by encouraging farmers to form groups or cooperatives, partnering with organizations to secure larger plots of land and pooling resources to overcome small landholding limitations and facilitate technology adoption.
3. Technological demonstrations should be organized frequently by extension service providers and line departments, particularly in areas with low adoption rates to highlight the advantages of new agricultural technologies.
4. Tailored training programs for different age groups and educational qualifications should be developed to bridge the adoption gap across age groups and educational qualifications.
5. Public-private partnerships (PPPs) should be encouraged to boost technology adoption.

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