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Informal social network attributes influencing climate-smart agricultural practices among farmers in Meghalaya

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Abstract

Agriculture, a sector with impressive increase in sustaining the livelihood security of farmers plays a vital role in ensuring global food security particularly under the growing challenges posed by climate change. India, being highly dependent on climate-sensitive agriculture, faces increasing risks from erratic rainfall, and declining natural resources. Meghalaya, a predominantly rainfed hill state in Northeast India, is especially vulnerable to climate-induced agricultural stresses. In this context, Climate-Smart Agriculture Practices (CSAPs) have emerged as an important strategy for enhancing productivity, resilience, and sustainability. Therefore, the present study was conducted in the Ri-Bhoi district of Meghalaya to examine the Informal Social Network (ISN) attributes associated with information seeking and sharing related to CSAPs among farmers. Also, study revealed the relationship between mass media exposure, Knowledge on CSA Practices on Adoption of CSA Practices. The study was undertaken in six adopted villages under College of Post Graduate Studies in Agricultural Sciences (CAU, Imphal) and ICAR Research Complex for North East Hill Region under Mera Gaun Mera Gaurav (MGMG) scheme. Using purposive and snowball sampling techniques, 60 respondents were selected, comprising ten farmers from each village. Data were collected through structured interviews and analysed using SPSS. The findings from Social Network Analysis all six villages using indicators such as degree centrality, eigenvector centrality, betweenness centrality revealed Khweng and Thadnongiaiw villages emerged as strategically influential networks, while Kdongulu demonstrated the strongest cohesiveness and communication efficiency. Friedman's test was employed in six villages within four domains of Crop Improvement (CI), Agricultural Advisory Services (AAS), Natural Resource Management (NRM) and Plant Protection (PP) within the six MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region to determine differences in ISN statistics across villages ($\chi^2 = 2.308$, $p = 0.805$) indicated similarity in information-seeking and sharing behaviour across villages.

Keywords: Informal social networks, climate-smart agriculture, information dissemination, degree centrality

Introduction

Agriculture remains the backbone of global food and livelihood security and is expected to play a critical role in feeding the projected world population of nearly 9.7 billion by 2050. Global food demand is anticipated to increase by approximately 60–70 per cent over the coming decades, thereby exerting enormous pressure on agricultural systems, natural resources, and rural livelihoods (FAO, 2023) [7]. Simultaneously, Climate Change (CC) has emerged as one of the most serious global challenges affecting agricultural sustainability, environmental stability, and socio-economic development. According to the Intergovernmental Panel on Climate Change Sixth Assessment Report (AR6), global surface temperature is projected to exceed 1.5°C during the twenty-first century unless substantial mitigation measures

are implemented urgently (IPCC, 2023). Such climatic disruptions are expected to severely impact crop yields, water availability, biodiversity, and rural livelihoods, particularly in developing countries with limited adaptive capacity. India is considered one of the most climate-vulnerable countries due to its high dependence on climate-sensitive sectors such as agriculture. Recent climate assessments indicate that India continues to remain among the countries most affected by extreme weather events globally (Germanwatch, 2025) [9]. Irregular monsoon patterns, rising temperatures, prolonged dry spells, and frequent floods have increasingly affected agricultural productivity, soil health, water resources, and farm income (Jatav *et al.*, 2024) [13]. Recent reports have highlighted that climate variability may reduce agricultural incomes by 15–

25 per cent in vulnerable rainfed regions if effective adaptation strategies are not implemented (Government of India, 2024) ^[10]. Moreover, increasing incidences of pest outbreaks, soil degradation, and declining groundwater resources have intensified production risks and threatened food security in several states of the country.

The northeastern region of India, particularly Meghalaya, is highly vulnerable to climate-induced agricultural risks due to its fragile hill ecosystems, predominantly rainfed agriculture, shifting cultivation practices, and socio-economic limitations. Meghalaya receives one of the highest annual rainfall levels in the world; however, recent climatic irregularities, including erratic precipitation, landslides, soil erosion, flash floods, and rising temperatures, have adversely affected agricultural production and livelihood security (Lyngdoh *et al.*, 2025) ^[15]. Agriculture contributes substantially to the state economy, and nearly 80 per cent of the rural population depends directly or indirectly on agriculture and allied activities for sustenance. Recent vulnerability assessments conducted in Meghalaya revealed that several districts and blocks fall under high to very high climate vulnerability categories due to poor infrastructure, low adaptive capacity, declining forest cover, and increasing climatic stresses (Lynrah *et al.*, 2025) ^[16]. These climatic challenges have increased the urgency for resilient agricultural planning and localized adaptation strategies in Meghalaya (Wahlang *et al.*, 2026) ^[20]. Climate Change not only affects agricultural production systems but also creates broader socio-economic consequences, including food insecurity, migration, livelihood instability, and water scarcity. Developing countries are disproportionately affected because of inadequate institutional support, poor access to technology, and limited financial resources for adaptation (Mekonnen & Hoekstra, 2023) ^[17]. In this context, Climate-Smart Agriculture (CSA) has emerged as a sustainable and strategic approach for addressing climate-related agricultural challenges. CSA integrates sustainable agricultural practices that improve productivity and income, enhance resilience and adaptation to climate change, and contribute to mitigation by reducing greenhouse gas emissions (FAO, 2024) ^[8]. Climate-smart practices such as crop diversification, integrated farming systems, agroforestry, conservation agriculture, efficient water management, climate-resilient crop varieties, integrated nutrient management, and digital agro-advisory services are increasingly being promoted worldwide to strengthen agricultural resilience (Lipper *et al.*, 2022) ^[14]. In India, several governmental and institutional initiatives, including the National Innovations in Climate Resilient Agriculture (NICRA), Paramparagat Krishi Vikas Yojana (PKVY), and digital agricultural extension platforms, have been introduced to encourage CSA adoption among farmers. However, the adoption rate of CSA practices among smallholder farmers remains uneven due to inadequate awareness, weak extension services, socio-economic barriers, poor access to information, and institutional constraints (Aryal *et al.*, 2023) ^[11]. Farmer decision-making regarding climate adaptation and CSA adoption is often influenced by social interactions, knowledge exchange, trust networks, and institutional linkages.

In recent years, Social Network Analysis (SNA) has gained increasing importance in understanding agricultural

knowledge dissemination, farmer-to-farmer learning, and technology diffusion processes. SNA provides insights into how information flows among farmers, extension agencies, researchers, local institutions, and community organizations (Dympep *et al.*, 2022) ^[6]. Informal Social Network Analysis (ISNA), in particular, examines informal relationships, communication patterns, and behavioural interactions within farming communities and organizations (Clifton & Webster, 2021) ^[4]. Such analyses help identify influential actors, information hubs, communication gaps, and collaborative structures that facilitate or hinder technology adoption and climate adaptation. Understanding these network dynamics is especially crucial in climate-vulnerable regions like Meghalaya, where indigenous knowledge systems, community interactions, and informal communication networks significantly influence farmers' adaptation behaviour (Springer & De Steiguer, 2022) ^[18]. Strengthening social networks and institutional collaborations can therefore accelerate dissemination of climate-resilient technologies, improve access to agricultural advisories, and enhance collective adaptive capacity among farming communities. Henceforth, this present study was undertaken to examine the ISN attributes and utilize key opinion leaders as bridge actors in these villages, also the study focussed extent of similarity of information seeking behaviour of respondents under adopted villages of CPGS-AS [CAU, Imphal], and ICAR RC for NEH Region.

Materials and Methods

Owing to the current execution of Mera Gaon Mera Gaurav programme by the two central institutes under Ministry of Agriculture and Farmers' Welfare, Govt. of India, namely (1) College of Post Graduate Studies -Agricultural Sciences (CAU, Imphal), and Indian Council of Agricultural Research- Research Centre for North East Hill Region at Umiam – 793 103, Ri-bhoi district of the state Meghalaya, this state and district had been selected purposively for the scientific pursuit. As the Umsning block has contiguous agriculturally important villages which had been adopted under Mera Gaon Mera Gaurav (MGMG) by both the institutes of College of Post Graduate Studies in Agricultural Sciences (CAU, Imphal) and ICAR Research Complex for North East Hill Region were selected purposively in the scientific study. Out of the 21 adopted villages of Umsning Block under MGMG by the CPGS-AS, three most agriculturally important villages namely, (1) Lairkhla, (2) Khweng & (3) Palwi; as well as three utmost agriculturally significant villages out of 16 adopted villages of Umsning Block under MGMG by the ICAR RC for NEH Region namely (4) Thadnongiaiw, (5) Kdonghulu & (6) Mawbri had been purposively selected for the scientific interrogatory. A key farmer who strictly followed CSAPs was identified in each of the identified villages, and implying the snowball sampling procedure, nine other farmers from the respective villages had been selected in order to constitute ten respondents from each village. Thereby, sixty respondents had been determined as sample of the study. Friedman Test was conducted to examine if there was any significant difference in information seeking and sharing of CSAPs by respondents in domains of Crop Improvement (CI), Agricultural Advisory Services (AAS),

Natural Resource Management (NRM) and Plant Protection (PP) within the six MGMG adopted villages. The data collected were coded, tabulated and analysed in accordance with the objectives of the study using appropriate statistical tools. The software used for data analysis included the R, SPSS version 25.0 and MS Excel 2010.

Results and Discussion

The integration of Informal Social Networks with modern analytical software and visualization tools enables researchers to examine network characteristics such as centrality, density, cohesiveness, and tie strength among stakeholders involved in agricultural systems

Table 1: Social Network Attributes of six villages of CPGS-AS and ICAR-NER under MGMG

S. No.	Network Attributes	V1 (Kdonghulu)	V2 (Palwi)	V3 (Lairkhla)	V4 (Mawbri)	V5 (Thadnongiaiw)	V6 (Khweng)
1.	Centrality						
	a. Degree Centrality	12	11	9	9	9	11
	b. Eigenvector Centrality	1.028	1.726	7.504	6.501	7.823	8.000
	c. Betweenness Centrality	7.916	9.083	8.166	8.166	9.561	9.75
	d. Closeness Centrality	0.66	0.60	0.642	0.66	0.64	0.642
2.	Cohesiveness/Graph Density	0.444	0.444	0.444	0.400	0.422	0.444
3.	Ties	45	45	45	45	45	45
4.	Homophily /Assortiveness	0.46 (-1to+1)	0.39 (1to+1)	0.35 (-1to+1)	0.39 (-1to+1)	0.38 (-1to+1)	0.41 (-1to+1)
5.	Average Degree	4 (1 – 9)	4 (1 – 9)	4 (1 – 9)	3.6 (1 – 9)	3.8 (1 – 9)	4 (1 – 9)
6.	Modularity	0.149 (0 –10)	0.057 (0 –10)	0.153 (0 –10)	0.129 (0 –10)	0.202 (0 –10)	0.152 (0 –10)
7.	Average Path Length	1.556 (1 – 3)	1.644 (1 – 4)	1.589 (1 – 3)	1.580 (1 – 3)	1.633 (1 – 3)	1.567 (1 – 3)
8.	Average Clustering Coefficient	0.46 (0 – 1)	0.39 (0 – 1)	0.35 (0 – 1)	0.39 (0 – 1)	0.38 (0 – 1)	0.41 (0 – 1)
9.	Network diameter	3	4	3	3	3	3
10.	Maximum In-degree	8	7	5	6	5	7
11.	Average In-degree	4	4	4	3.6	3.8	4
12.	Maximum Out-degree	4	4	4	4	4	4
13.	Average Out-degree	4	4	4	3.6	3.8	4
14.	Average weighted degree	19	4	20	20.2	20.3	19.5
15.	Weighted In-degree	49	7	34	36	29	35
16.	Weighted Out-degree	24	4	26	23	27	25

The social networks of the six villages in Ri-Bhoi district are generally well-connected, with relatively high-density values (0.400–0.444) and short average path lengths (1.556–1.644), indicating favourable conditions for information dissemination. Among the villages, Khweng and Thadnongiaiw emerge as the most influential networks due to the presence of high betweenness centrality, while

Kdongulu exhibits the strongest cohesiveness and communication efficiency. These findings suggest that extension agencies and rural development programmes can effectively utilize key opinion leaders and bridge actors in these villages to accelerate the dissemination of agricultural innovations, technologies, and community development initiatives.

Table 2: Key Characteristics of selected six villages w.r.t Network Attributes

S. No.	Village	Key Network Characteristic
1.	Kdongulu	Most cohesive and fastest communication network with strong local clustering.
2.	Palwi	Highly integrated network with minimal subgroup formation but relatively lower influence concentration.
3.	Lairkhla	Strong influence network where opinion leaders are connected to other influential actors.
4.	Mawbri	Less dense network but characterized by strong interaction intensity among existing ties.
5.	Thadnongiaiw	Strong bridge actors and highest subgroup formation; information flow depends on key intermediaries.
6.	Khweng	Most strategically influential network with highest eigenvector and betweenness centrality.

Relationship among Mass Media Exposure, Knowledge on Climate-Smart Agriculture, and Adoption Behaviour of Climate-Smart Agricultural Practices among Farmers

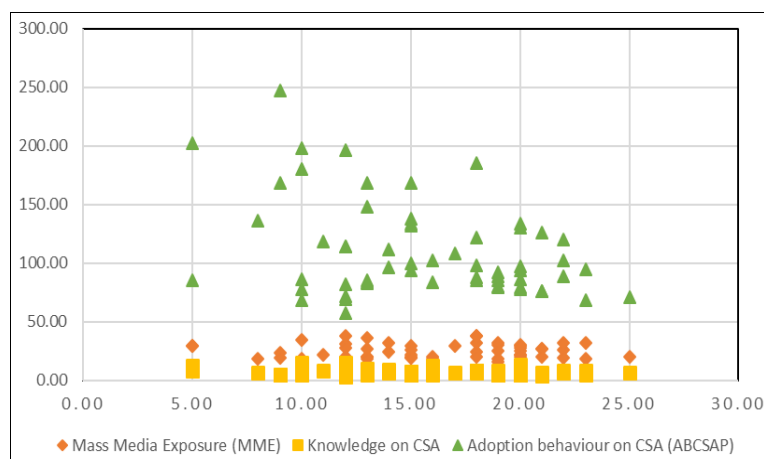


Figure Note: The scatter plot indicates a positive association among mass media exposure, knowledge on climate-smart agriculture, and adoption behaviour of climate-smart agricultural practices

Fig 1: Scatter Plot depicting Mass Media Access, Knowledge on CSA and Adoption behaviour on CSA (ABCSAP)

The scatter plot illustrates the association between Mass Media Exposure (MME), Knowledge on Climate-Smart Agriculture (CSA), and Adoption Behaviour of Climate-Smart Agricultural Practices (ABCSAP) among the respondents. The distribution of data points indicates a positive relationship among the variables, suggesting that respondents with higher exposure to mass media sources tend to possess greater knowledge regarding CSA practices and exhibit higher levels of adoption behaviour. These results emphasize the need for targeted media-based extension interventions to promote wider adoption of CSA practices among farming communities.

Friedman's Test for Examining Significant Difference in the ISN Statistic of different MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region

In the scientific inquiry, an attempt had been contrived to examine if there was any significant difference in information seeking and sharing of CSAPs by respondents in domains of Crop Improvement (CI), Agricultural Advisory Services (AAS), Natural Resource Management (NRM) and Plant Protection (PP) within the six MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region as mentioned in Table.3. The non-parametric Friedman Test had been administered to observe the hunch in the study. The following null and alternate hypotheses had been formulated as outlined in the succeeding statements.

H₀: There is no significant difference in ISN statistic of six MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region.

H₁: There is significant difference in ISN statistic of six MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region.

Table 3: Friedman-Test Examining Significant Difference in the ISN Statistic of different MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region

S. No.	χ^2	df	p
1	2.308	5	0.805

Referring the end result of Friedman Test, as depicted in Table 3, it could be revealed that with the χ^2 value of 2.308, which is relatively low states that the social network analysis indicators across the six villages are fairly similar. d.f. = 5 and $p = 0.805$, stating that we fail to reject the null hypothesis and conclude that the observed differences are not statistically significant. Henceforth, H_0 is accepted and H_1 is rejected. The study actuated that information seeking and sharing of CSAPs by respondents in domains of Crop Improvement (CI), Agricultural Advisory Services (AAS), Natural Resource Management (NRM) and Plant Protection (PP) within the six MGMG adopted villages of CPGS-AS, CAU, Imphal and ICAR RC for NEH Region were very similar.

The findings revealed that informal social networks play a significant role in facilitating the dissemination of Climate-Smart Agricultural Practices (CSAPs) among farmers. The high density, short path lengths, and influential actors identified in Khweng and Thadnongiaiw villages indicate efficient information exchange mechanisms. Similar findings were reported by Dympep *et al.* (2022) [6], Valente (1996) [19], Borgatti *et al.* (2018) [3] who observed that cohesive farmer networks enhance agricultural knowledge sharing and technology adoption. However, the results differ from those of Conley and Udry (2010) [5], Isaac *et al.* (2007) [12], and Bandiera and Rasul (2006) [2], who reported significant variations in information flow and innovation diffusion across communities due to heterogeneous social structures and socio-economic differences. The non-significant Friedman test in the present study suggests relatively homogeneous information-seeking behaviour among the selected villages.

Conclusion

The study highlighted the importance of informal social networks in facilitating information exchange related to Climate-Smart Agricultural Practices (CSAPs) among farmers in Ri-Bhoi district of Meghalaya. The findings from Social Network Analysis all six villages using indicators such as degree centrality, eigenvector centrality,

betweenness centrality revealed Khweng and Thadnongaiw villages emerged as strategically influential networks, while Kdonggulu demonstrated the strongest cohesiveness and communication efficiency. The Friedman test indicated no significant differences in network characteristics across the six villages, suggesting similar information-seeking and sharing behaviour among respondents. Nonetheless, study emphasized the need to strengthen farmer-led networks and engage key opinion leaders and bridge actors to enhance dissemination, adoption, and sustainability of climate-smart agricultural practices in Meghalaya.

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