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# Climate-smart Agricultural Practices in Agro-climatic Zones of Meghalaya: A Social Network Analysis

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author AD collected the data, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RJS designed the study. Authors RJS, LH and RS assisted in the analyses of the study and refined the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** To understand the flow of information of Climate Smart Agricultural (CSA) practices among the farmers, the factors that impede this flow and the impact of the social network on adapting CSA practices.

**Place and Duration of Study:** The study was conducted in hilly state, Meghalaya, India between August 2016 and April 2017.

**Methodology:** A sample of 120 farmers was selected from agriculturally vulnerable villages to climate change by snowball sampling. The villages were selected from two Agro-climatic zones (ACZs) of the state, Meghalaya. UCINET software was utilised for analysing the Social Network Analysis (SNA) of the community with the performance index used to measure the impact in adopting CSA practices.

**Results:** The network centralization index obtained in Tropical ACZ was relatively high (0.63) depicting a fragile social network as farmers relied on certain central actors for information and if these actors were to be removed, many farmers would be left isolated. However, in Sub-tropical ACZ, a low index (0.37) was attained implying that farmers had maximum connections in the

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network. Very low cohesion density measures (<0.05) was obtained in both the ACZs portraying a slow rate of diffusion of information on CSA in the farming community. Further, the homophily index of SNA indicated that the farmers tend to associate more with other farmers having similar socio-economic characteristics. The impact of the social networks in both of the ACZs were highest (68.30%) under low, and (63.30%) under the medium adoption levels of CSA practices in Tropical and Sub-tropical ACZs.

**Conclusion:** Hence improving access to climate information is an important step to improve the livelihood of people in such variable conditions. With a better understanding of the social factors that influence the flow of knowledge and the adoption of CSA practices in the agricultural sector, researchers and policy makers could be able to identify and reduce barriers to technology diffusion and adoption.

*Keywords: Climate smart agriculture; social network analysis; homophily index; mitigative and adaptative performance index.*

## 1. INTRODUCTION

Climate change has already significantly impacted agriculture [1] and is expected to further impact directly and indirectly food production. Agriculture however, is not just a victim of climate change; it is also one of the components causing climate change. Therefore, to increase agricultural production without increasing greenhouse gas emissions from agricultural activities, a range of mitigation and adaptation agricultural practices which come under the heading of ‘Climate-Smart Agriculture’ (CSA) has been introduced. Climate Smart Agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate [2]. CSA includes many of the field-based and farm based sustainable agricultural land management practices already in wide use, such as conservation tillage, agro-forestry, residue management, enhancement of soil carbon sequestration, improved grazing management, the restoration of organic soils and restoration of degraded lands [2].

Adaptation of CSA technologies, however is rather complex as it is an interplay between perceptions, communication and knowledge. The adoption of CSA techniques occurs within a social setting and is initiated by awareness of the existence of the techniques through the process of information exchange [3]. Several studies [4,5,6,7,8] have highlighted that interpersonal communication with agricultural stakeholders *viz.,* friends, relatives, fellow farmers and extension personnels were the main sources to gain information related to climate change. These actors in the information exchange process play different roles which determine the flow of such information and resultant communication patterns. An understanding of how this information flows through a social system is crucial in the development of agricultural communication approaches. Social Network Analysis (SNA) enhances the understanding of how information flows through the agricultural stakeholders and the factors that facilitate or impede the flow. SNA is a methodology that has gained currency due to its ability to combine graph theory, statistics and computer programmes to produce visual sociograms and indices that assign value to relationships in a network [9].

SNA was defined as a social made up of a set of actors and the relationships between these actors [10]. SNA was referred to as social networks and institutional actors (organizations, individuals, interest groups, etc.) and their linkages (socio-institutional relationships), mapping the influence and the exchange of information to assess adaptive capacity [11]. SNA depicts the structure of social networks, how people have either weak or strong ties and to identify the gaps in networks. Embedded in these interactions is a flow of knowledge, ideas and information that shapes farmers’ decision to adopt to CSA practices [12]. Strong social networks have been shown to improve collaborative governance processes by facilitating the generation, acquisition and diffusion of different types of knowledge and information by overcoming many of the traditional barriers associated with knowledge sharing [13]. Studies recently have acknowledged the use of social networks in rural communities [14,15]. This paper uses SNA to analyse the social interactions that shape farmers’ decision-making when adopting CSA practices.

## 2. MATERIALS AND METHODS

### 2.1 Study Area and Sampling Method

The research was conducted in hilly terrain, Meghalaya one of the major agricultural regions of North East India in which the population has a large dependence on natural resources, crop area is under rainfed and is an area highly vulnerable to climate variability and climate change. The outcome of climate change in Meghalaya will be excessively high, due to three main reasons – its geographical location, high dependence of people on natural resources that are highly sensitive to climate change and low adaptive capacity due to fewer amounts of resources available to them. Keeping in view the agricultural importance, the Tropical and Sub-tropical agro-climatic zones (ACZs) of the state were selected for the study. Further, the most agriculturally vulnerable community and rural development block (CRDB) to climate change was purposively selected. Through cluster sampling, four contiguous clusters of villages from each CRDB was finalized and 60 farmers from each CRDB from the two ACZs were selected using snowball sampling which included organisational institutes.

Data in this study was obtained through two steps. First step was through group discussions with randomly selected group of 20–25 individuals including village leaders, farmers and block officers from each selected block in each district to document the common existing CSA technologies as shown in Table 1. Any practice or technology that supports at least one of the three pillars: productivity, resilience and mitigation in agriculture under climate change and variability was considered a CSA technology. The second step of data collection was through a semi-structured questionnaire to investigate the flow of information of CSA technologies among the farmer-respondents.

### 2.2 Data Analysis

In order to study the characteristics on pattern of distribution of relationship among farmers-respondents for transfer of information on CSA strategies, SNA has been performed using the software UCINET 6.0. The SNA of farmers on CSA in the study incorporated Centrality measures and Cohesiveness measure. The different indicators used in the study are briefly described in Table 2.

**Table 1. Common existing Climate Smart Agricultural (CSA) technologies practiced in the study area**

| S. no. | CSA technologies practiced |
|---|---|
| 1. | Inter-cropping |
| 2. | Use of pest and disease resistant crops |
| 3. | Crop rotation |
| 4. | Increased application of organic matter |
| 5. | Early planting or harvesting |
| 6. | Usage of bio-control agents |
| 7. | Investing in water storage |
| 8. | Rain water harvesting |
| 9. | Mulching |
| 10. | Integrating of scientific and indigenous methods |
| 11. | Construction of poly-house or shady net |
| 12. | Storing of food surplus |
| 13. | Low cost storage structures of produce for next season |
| 14. | Maintaining insurance |

**Table 2. Social network analysis elements and their relationship to the present study**

| Network property | Description relation to the present study |
|---|---|
| Centrality | Measure of the number of ties that a node has relative to the total number of ties existing in the network as a whole; centrality measures include degree, closeness, and betweenness. |
| Degree | Total number of ties a node has to other nodes. A node is central, when it has the higher number of ties adjacent to it. |
| Betweenness | Number of times a node occurs along the shortest path between two others. |
| Cohesiveness | Degree to which farmers were connected directly to each other by cohesive bond. |
| Network density | Ratio of actual numbers of relationships between farmers observed in the network and the total number of relationships that are possible within the network. |
| Homophily | Tendency of individuals to associate with those similar to themselves. |

Social network analysis has depicted the flow of information on CSA practices among the farmers, thus to analyse if these social interactions had shaped farmers' decision-making for adopting CSA practices, the adaptation or performance of CSA by the farmers selected in the study was analyzed using the performance index on mitigation and adaptation (PMA) practices developed by [16].

$$PMA = \frac{X_1 + X_2 + X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + X_n}{N} * 100$$

Where, $X_1 + X_2 + X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + X_n$ are the performed continuum value (3, 2 or 1) to the first, second, third ………. $n^{th}$ questions and N is the maximum score possible to secure.

## 3. RESULTS AND DISCUSSION

### 3.1 Centrality Measures of the Social Network of Farmers

Analyzing the in-degree and out-degree of the farmers in the identified social network (Table 3) unveiled that the average in-degree and out-degree was higher in Sub-tropical ACZ (3.188) than Tropical ACZ (2.797) with a maximum in-degree and out-degree in 28 and 4 in Tropical ACZ and 39 and 5 in Sub-tropical ACZ respectively. This connotes that a node/farmer receives information on CSA practices from 28 sources in Tropical ACZ while in Sub-tropical ACZ a farmer receives information from 39 sources. However, the dissemination rate is low in both the ACZs to roughly 4-5 nodes.

The network centralization index obtained was relatively different in the two ACZs. In the Tropical ACZ, a high centralization index of 0.63 was obtained while in Sub-tropical ACZ, a low centralization index of 0.37 was obtained. The high centralization index in Tropical ACZ threatens the flow of information of CSA among the community or farmers as this indicated that farmers in this network relied on a certain source or actor for information on CSA practices. This is risky as if and when these central actors were to be removed or disconnected from the network, many farmers would be left isolated. The low centralization index of Sub-tropical ACZ, however is a good sign as this indicated that farmers had maximum connections in the network hence the high in-degree value of 39. Moreover in Sub-tropical ACZ, the existence of institutes or organizations like Indian Council of Agricultural Research (ICAR), Krishi Vigyan Kendra (KVK) and Self-Help Groups (SHGs) can be observed which further strengthens the network. The social network diagram of both the ACZs is depicted in Figs. 1 and 2.

On analyzing the betweeness centrality of the farmers' social network (Table 3), it was found that the network betweeness centralization in both the ACZs was less than 5 percent which was very low for a large social network. This low percentage implied that there were very few information brokers within the networks and many nodes/actors in the networks were isolated. However, this finding may also imply that the networks were significantly strong as the nodes had the shortest distance to their information source without any need of an intermediary.

Similarly, on analysing the cohesion measures of the networks, a very low density was obtained in both the ACZs of 0.059 and 0.051 in Tropical ACZ and Sub-tropical ACZ respectively. This low cohesiveness in the networks leads to slow rate of diffusion of information on CSA in the farming community. The slow rate maybe because the farmers have not yet experienced any serious natural calamity of climate change in their region which provoked betweeness and hence farmers did not give much importance to CSA practices.

Further, the identified social network in Sub-tropical ACZ had 37 components with a fragmentation of 0.817 while in the Tropical ACZ, only 3 components was observed with a very low fragmentation of 0.08. Thus, the social network of farmers was highly scattered in Sub-tropical ACZ while in the Tropical ACZ, it was close-knit. The disarray of the network in Sub-tropical ACZ does not present a good structure for flow of information, however, the high number of in-degree nodes (39) along with an improve betweeness centralization by means of integrating facilitators considering the spatial distribution of the farmers can improve the network. The close-knit network of Tropical ACZ, although depicts a good structure for disseminating information however, is highly threatening as a loss of one or two central farmers or nodes could shatter the social network.

### 3.2 Homophily of the Social Network of Farmers

The homophily index of the farmers in the identified social networks in Tropical ACZ and

Sub-tropical ACZ depicted that farmers in these communities do tend to associate or linked better with other farmers of similar characteristics and status. In both the ACZs of Meghalaya, farmers portrayed to have more association and share much of their information with other farmers having similar socio-economic characteristics *viz;* landholding (Fig. 2), annual income and information communication pattern (Table 4). Moreover, in the Tropical ACZ, the homophily index revealed that gender also played an important role in linking or connecting farmers to other farmers who were of the same gender (Fig. 1). The social network of farmers in the two ACZs tend to socialise or mix with other farmers of similar socio-economic characteristics which thus have lead to less cohesiveness in the identified social networks.

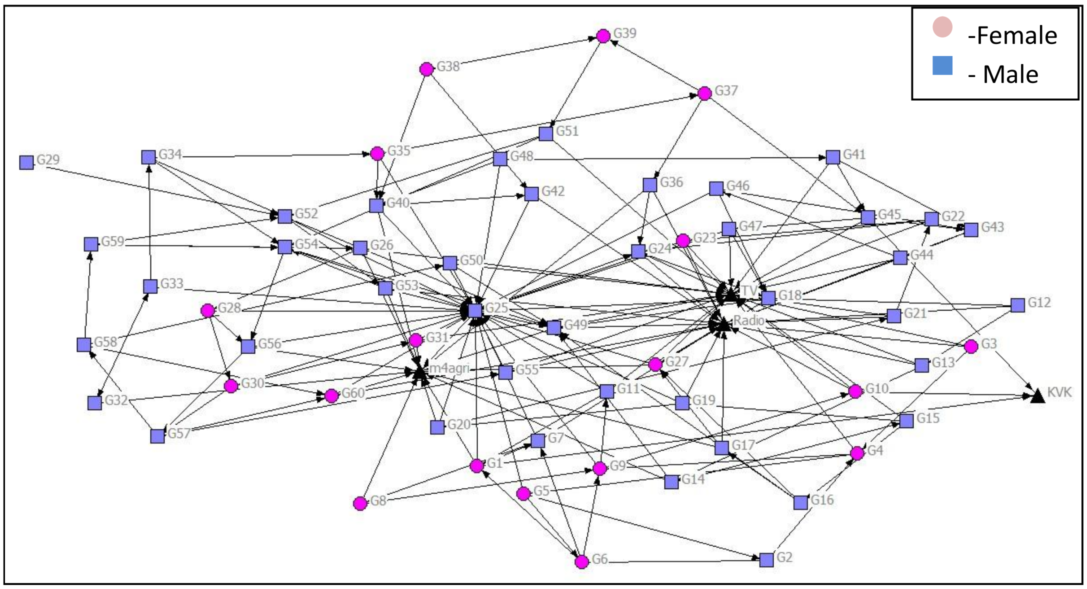


**Fig. 1. Social network analysis of farmers in tropical zone**

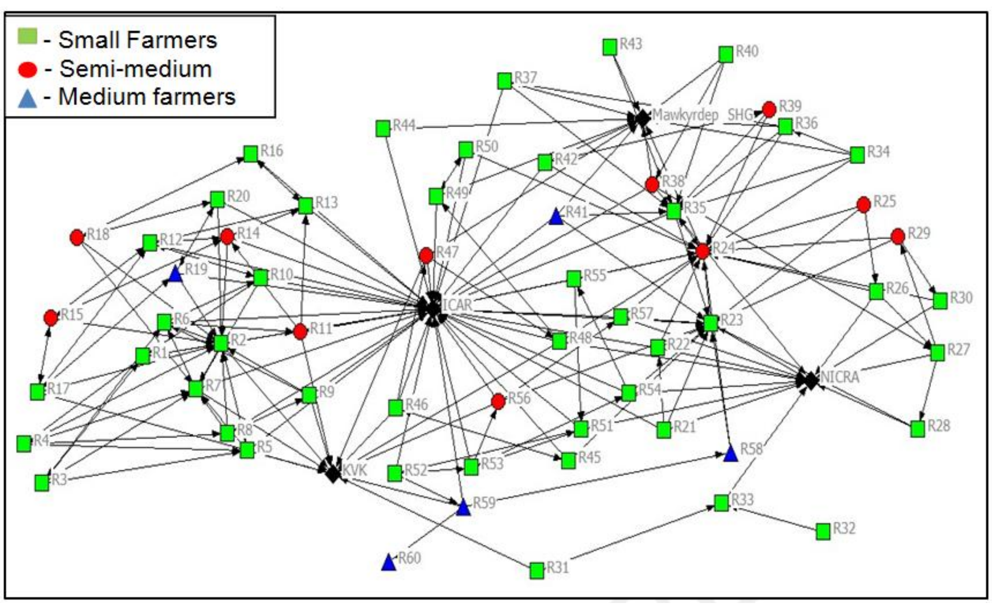


**Fig. 2. Social network analysis of farmers in sub-tropical ACZ**

**Table 3. Social network measures of the farmers**

| Particulars | Measures | Tropical | Sub-tropical |
|---|---|---|---|
| Centralization | Average In-Degree | 2.797 | 3.188 |
| | Maximum In-degree | 28 | 39 |
| | Average Out-Degree | 2.797 | 3.188 |
| | Maximum Out-degree | 4 | 5 |
| | Network Centralization Index | 0.63 | 0.37 |
| | Network Betweeness Centralization | 4.73% | 2.68% |
| Cohesion | Density | 0.059 | 0.051 |
| | Components | 3 | 18 |
| | Fragmentation | 0.09 | 0.817 |

**Table 4. E-I Homophily Index of farmers of the selected blocks**

| Sl. no. | Particulars | E-I Homophily index | |
|---|---|---|---|
| | | Tropical ACZ | Sub-tropical ACZ |
| 1. | Age | 0.316 | 0.549 |
| 2. | Gender | -0.433 | 0.431 |
| 3. | Landholding | -0.083 | -0.116 |
| 4. | Annual Income | -0.183 | -0.271 |
| 5. | Cosmopoliteness | 0.366 | 0.382 |
| 6. | Mass media | 0.167 | 0.205 |
| 7. | Information Communication Pattern | -0.05 | -0.313 |

**Table 5. Adaptation/performance of CSA practices by farmers**

| Category | Tropical ACZ | Sub-tropical ACZ |
|---|---|---|
| Low | 38 (68.30) | 15 (25.00) |
| Medium | 16 (21.70) | 38 (63.30) |
| High | 6 (10.00) | 7 (11.70) |

**Note : figures in parentheses in percentile*

### 3.3 Adaptation or Performance of CSA Practices by Farmers

The adoption level for CSA practices by the farmers in the identified social network in the Tropical ACZ and Sub-tropical ACZ have been categorised into three levels -low, medium and high (Table 5). In this study it was observed that the highest percentage of the farmers in the Tropical ACZ (68.30%) were in the low level of adaptation, while in the case of Sub-tropical ACZ, majority of the farmers' (63.30%) were under medium level of CSA practices. Such lopsided distribution on low adaptation level in Tropical ACZ was due to lack of awareness and knowledge on CSA practices resulting from the high network centralization index and low betweeness centralization index. The medium level of competency among farmers in Sub-tropical ACZ was due to involvement of agricultural stakeholders on mitigative and adaptive practices which lead to awareness and knowledge of climate smart practices.

## 4. CONCLUSION

Availability of climate information is a prerequisite for mitigating and adapting the adverse effect of climate variability, and capitalizing on beneficial effect, especially in Meghalaya where the livelihood and even lives of its people depend on natural climate. There are a number of stakeholders in the agricultural sector who are sources of climate information and who influence the multidirectional flow of information. Hence the study utilized social network analysis (SNA) to analyze the flow of CSA information and knowledge in a community. Strong social networks have shown to improve generation, acquisition and diffusion of CSA information in the community. The application of SNA to understand the diffusion and adoption of CSA practices in agriculture has the potential to improve the effectiveness of climate change mitigation and adaptation programmes. Moreover, the homophily index of SNA indicated that farmers tend to associate more with others who have similar socio-economic characteristics, implying farmers do not act unilaterally, instead they collaborate, consult and negotiate. Adoption level of CSA practices was found to be low and moderate in Tropical and Sub-tropical ACZ, hence improving access to climate information is an important step to improve the livelihood of people in such variable conditions. With a better understanding of the social factors that influence the flow of knowledge and the adoption of CSA practices in the agricultural sector, researchers and policy makers could be able to identify and reduce barriers to technology diffusion and adoption.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Lobell BD, Schlenker W, Roberts JC. Climate trends and global crop production since 1980. Science. 2011;333(6042):616-620.
2. FAO. Climate-smart agriculture: Policies, practices and financing for food security, adaptation and mitigation; 2010.
   (Accessed 26 September 2015)
   Available:http://tinurl.com/65nfr7k
3. Mutoko MC, Rioux J, Kirui J. Barriers. Incentives and benefits in the adoption of climate-smart agriculture: Lessons from the MICCA pilot project in Kenya. FAO; Food and Agriculture Organization of the United Nations FAO, Rome; 2015.
4. Churi AJ, Mlozi MRS, Tumbo SD, Casmir R. Understanding farmers information communication strategies for managing climate risks in rural semi-arid areas, Tanzania. Intl. J. Information and Communication Technology Res. 2012; 2(11):838-845.
5. Rehman F, Muhammad S, Ashraf I, Mahmood KC, Ruby T, Bib I. Effect of farmers' socioeconomic characteristics on access to agricultural information: Emperical evidence from Pakistan. The J. of Animal & Plant Sciences. 2013;23(1): 324-329.
6. Mwalukasa N. Agricultural information sources used for climate change adaptation in Tanzania. Library Review. 2013;62(4/5):266-292.
7. Umunakwe PC, Nnadi FN, Chikaire J, Nnadi CD. Information needs for climate change adaptation among rural farmers in Owerri West Local Area of Imo State, Nigeria. Agrotechnology. 2014;3:118.
   DOI: 10.4172/2168-9881.1000118
8. Yohanna I, Ndaghu AA, Barnabas BP. Sources of information on climate change among arable crop farmers in Adamawa State, Nigeria. J. of Agriculture and Veterinary Science. 2014;7(8):32-36.
9. Othieno JO. Social network analysis of climate change adaptation communication in Makueni country. Ph.D. Thesis, Submitted to University of Nairobi, Kenya; 2014.
10. The Institute for Sustainable Futures (ISF). An introduction to social networks for engaging the community in climate policy; 2014.
   (Accessed 04 August 2016)
   Available:www.isf.uts.edu.au
11. Bharwani S, Downing TE, Varela OC, Blanco I, Esteve P, Carmona G. Social network analysis: Decision support methods for adaptation, MEDIATION Project, Briefing Note 8; 2013.
   (Accessed 12 December 2015)
   Available:https://www.sei-international.org/mediamanager/documents/Publications/sei-mediation-briefing8-social-network-analysis.pdf
12. Neufeldt H, Negra C, Hancock J, Foster K, Nayak D, Singh P. Scaling up climate-smart agriculture: Lessons learned from South Asia and pathways for success. ICRAF Working Paper No. 209. Nairobi, World Agroforestry Centre; 2016.
   DOI:http://dx.doi.org/10.5716/WP15720.PDFs
13. Bodin O, Crona B, Ernstson H. Social networks in natural resource management-What's there to learn from a structural perspective? Eco. & Society. 2006;11.
14. Westerhoff L, Keskitalo ECH, Juhola S. Capacities across scales: Local to national adaptation policy in four European

countries. Climate Policy. 2011;11:1071–1085.
15. Yun SJ, Ku D, Han JY. Climate policy networks in South Korea: Alliances and conflicts. Climate Policy. 2013;14:283–301.
16. Dympep A, Singh RJ, Chauhan J, Pandey DK, Hemochandra L. Standardize index for measuring performance of farmers on mitigation and adaptation practices of climate change. Indian Res. J. Ext. Edu. 2016;16(3):93-96.



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