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Social Network Analysis of Information Exchange among Beekeepers in Oyo State, Nigeria

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Abstract

Information sharing and exchange are significantly influenced by social network that exist among people. Therefore, the study analysed the social network facilitating information exchange among beekeepers in Oyo State, Nigeria. The study assessed the attributes of the beekeepers, determined ego-centric and socio-centric network structures and identified dominant information topics exchanged within beekeepers' networks. *Data were collected through a structured interview schedule.* Census technique was used to 235 active beekeepers across all the seven zones in the State. *Findings revealed that beekeepers' association was dominated by small-holder beekeepers. Ego-centric analysis showed that only one individual recorded a betweenness-centrality score of 1.0 across all zones, indicating strong influence within the network. Socio-centric analysis showed low graph densities across zones: Oke-Ogun I (0.02), Oke-Ogun II (0.05), Ogbomoso (0.09), Ibarapa (0.08), Oyo (0.07), and Ibadan (0.04), suggesting weak interconnectedness and reliance on diverse information sources. Security issues (43.7%) and management practices (25.7%) were the major discussion topics. The study recommends that extension services should engage network stars for information dissemination and provide capacity-building training to sustain network effectiveness.*

Keywords: Social network analysis, beekeeping; agricultural communication.

Introduction

Amidst the economic challenges bedevilling Nigeria, the potential of honey production in ameliorating the situation cannot be overstated. Azeez (2022) posited that the economic potential of honey production is capable of fostering foreign exchange earnings for the country through exportation of honey and other bee products such as wax and propolis. More so, it can also serve as a means of poverty eradication among rural households, women and youths through job creation along the honey production value chain because of the low entry requirement (Azeez, 2022; Abro et al., 2022; Prodanović et al, 2024; Hashmat et al., 2025). It is argued that beekeeping can be used as an income-generation supplement that can be combined with crop and livestock

farming with low labour and land demands (Musumba et al., 2022 & Prodanović et al, 2024). It helps with additional income during lean agricultural seasons and can support investment in farm inputs, education, and food, strengthening resilience to shocks (Abro et al., 2022; Mutua et al., 2023; Hashmat et al., 2025). It also has enormous support for food security and nutrition (Abro et al, 2022 & Prodanović et al, 2024).

Despite the enormous economic potential of beekeeping, its full benefits have not been adequately realised in the country due to limited access to timely and credible information on improved beekeeping management practices, as well as inadequate training on modern techniques, credit facilities, market access, and technical support (Azeez, 2022; Mutua et al., 2023; Hashmat et al., 2025). Information dearth has been observed to be one of the bases for low productivity and widespread poverty incidence amongst smallholder farmers, especially in Africa (Izuchukwu et al. (2023).

Dissemination of agricultural information is largely handled in Nigeria through agricultural extension services, which are currently not functioning optimally, especially the public extension services, as a result of financial constraints, farmers' literacy status and widespread farming (Ojo et al., 2024; Mohammed, 2024; Chekene & Shehu, 2025; Felix et al., 2025; Ubandoma et al., 2025). This has led to the use of different approaches and strategies for the dissemination of agricultural information. Hence, receiving agricultural information among resource-poor farmers is taking place within a social system network or an association through a social learning process. Given the significance of social learning, there is growing interest and attention on the impact of farmers' information (social) networks and social systems with theoretical and empirical literature richness (Mohammed & Abdulai, 2022; Abdulai, 2023). Social networks can be in the form of membership of an association, age-group association, cooperating society *et cetera* (Azeez, 2022).

Social networks play a vital role in the transferring and sharing of knowledge among people in a social system, which may be in form of social influence or social interaction effects. According to Beaman et al. (2021), there are positive effects of social learning on adoption of agricultural practices among farmers. More so, Bogado et al. (2024) mentioned that there is a strong connection between farmers' social network and adoption of sustainable agricultural practices. Farmer-to-farmer communication networks help African farmers to embrace sustainable practices by allowing them to learn directly from peers who share their local challenges and insights. The mechanism is based on power of social interactions which enhance sharing of knowledge, learning activities and exchange of information (Izuchukwu, 2023).

It is therefore important to analyse how the social networks are facilitating information flow or spread in a social system through social networks. The main aim of network analysis is to identify the relationships between people. The method is based on informal relationships, indicating how existing informal interactions ease or hinder the transfer of information and knowledge or more concrete products and cash. (Iacopini et al., 2024; Liu et al., 2023; Rashidi et al., 2024). The relationship is represented by a socio-gram (Franzato & Diehl, 2025). A sociogram is used to express this interaction (nodes and ties). It is a graph that depicts the social relations in a group. Social Network Analysis (SNA) helps to reveal the communication patterns that exist in a given community, group or particular set of farmers. SNA is a technique that is based on graph theory (Goldenberg, 2021). This analysis has been extensively used in communication studies and in the field of agricultural extension, such as Goldenberg (2021), Abdulai (2023), Singh et al., 2024; Golędzinowski, 2024; Morrison et al., 2025).

The analysis is based on the assumption of the importance of relationships among interacting units or nodes (individual farmers) (Abdulai, 2023). A fundamental component of SNA is the relations defined by the linkages among the units or the nodes.

Currently, a few studies have been conducted in the field in Nigeria, and specific work on the social network analysis on beekeeping is still lacking. Hence, this study tends to bridge this gap in knowledge. There are limited studies related to agricultural extension and communication that have attempted to use this approach. Hence, this study will bridge this gap in knowledge.

The following objectives guided the study to:

i. examine ego-centric and socio-centric network structures; and
ii. identify dominant information topics exchanged within beekeeper networks.

Methodology

The study was carried out in Oyo State, Nigeria, which is one of the states in southwest Nigeria. The study adopted a census approach to cover the entire population of registered beekeepers in the State who are members of the Federation of Beekeepers' Association of Nigeria (FEBKAN). A complete enumeration was conducted across all seven (7) FEBKAN zones in the state. Consequently, all 235 active beekeepers across these zones were included as respondents for the study.
A structured interview technique was employed to elicit information from respondents using a questionnaire developed in line with the objectives of the study. The network boundary was restricted to registered members of the selected beekeepers' associations in the study area. Consequently, respondents were asked to nominate only fellow association members with whom they had exchanged beekeeping-related information during the preceding 12 months.

Relational data were collected using a name generator question. Each respondent (ego/node) was asked to recall and nominate a minimum of one and a maximum of five fellow association members (alters/actors) who had either provided or received beekeeping-related information within the previous year. The maximum of five nominations was adopted based on recommendations from previous social network studies (Stadel & Stulp, 2021; Peng & Perry, 2022), which indicate that limiting nominations to between three and five key contacts effectively captures the most influential and frequently used information ties while reducing respondent fatigue and recall bias. In addition, applying a uniform nomination limit across all respondents enhances the comparability of network data and minimizes interview burden.
For each nominated alter, respondents identified the primary focus of the information exchanged. These relational ties were subsequently coded numerically and assigned different colours for network visualization and analysis.

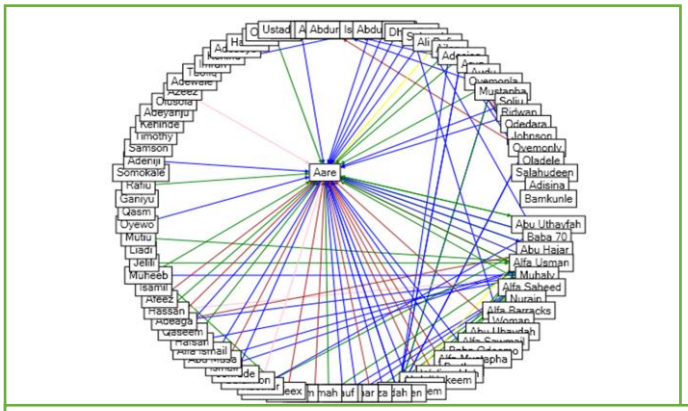
The data obtained were analysed using NodeXL, Statistical Package for Social Sciences (SPSS), and Microsoft Excel. NodeXL version 1.0.1.92 was used to analyse the relational data of beekeepers and to generate the sociograms at zonal levels, while SPSS was used for descriptive statistics such as frequencies. NodeXL was integrated into Microsoft Excel as an add-in. A total of 235 responses were obtained and analysed.
Both graph-level (socio-centric) and vertex-level centrality analyses were conducted. The graph-level metrics included graph type, number of vertices, unique edges, edges

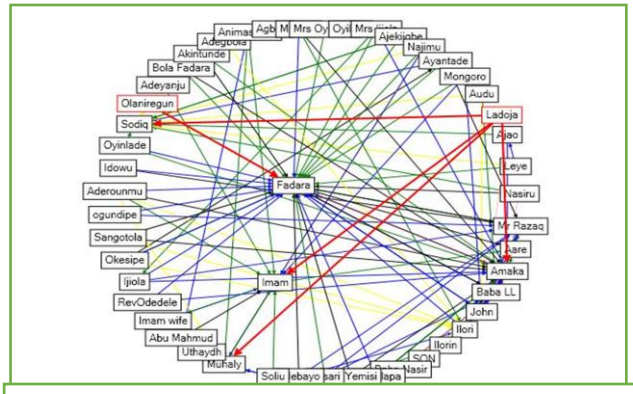
with duplicates, total edges, self-loops, and graph density. The sociograms generated were directed, indicating the direction of information flow among actors.
To identify network stars (opinion leaders), respondents were asked to list a minimum of one and a maximum of five fellow association members whom they consulted on beekeeping management practices or from whom they obtained equipment during the previous farming season. The primary focus of each interaction was recorded as the information domain and coded using colours: green for beekeeping management practices (e.g., site selection, hive installation, equipment sharing, and hive construction), blue for security issues (theft and vandalisation), yellow for harvesting and marketing, brown for training and induction, black for association matters, and pink for finance.

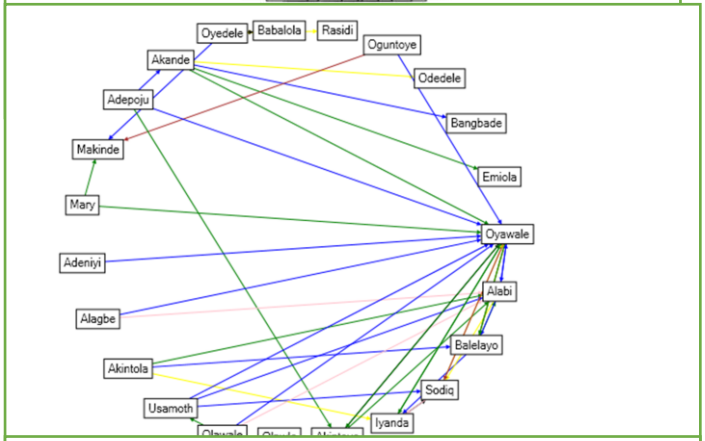
Vertex-level centrality measures computed in NodeXL included degree centrality, in-degree, out-degree, betweenness centrality, closeness centrality, eigenvector centrality, and clustering coefficient. These metrics were used to determine the most influential actors within each zonal network. The centrality values presented in the study were reported as generated by NodeXL version 1.0.1.92. Degree, in-degree, and out-degree represent the number of direct ties associated with each actor. Betweenness centrality values were expressed on the scale produced by the software, while closeness centrality values were reported as unnormalized measures of proximity within the network; consequently, values greater than 1 may occur depending on the network structure and the computational procedure implemented in NodeXL.

Results and Discussion

Ego-centric network structures of Beekeepers Across the zones







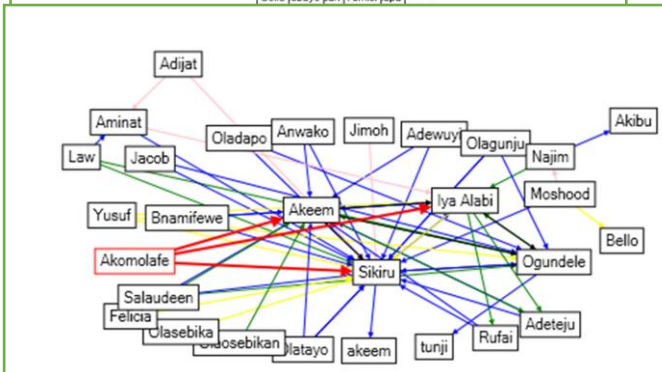


Figure 4V: Socio-gram of Beekeepers in

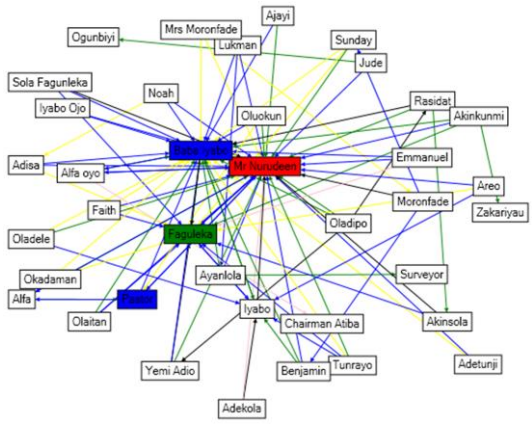


Figure 5: Socio-gram of Beekeepers in Oyo

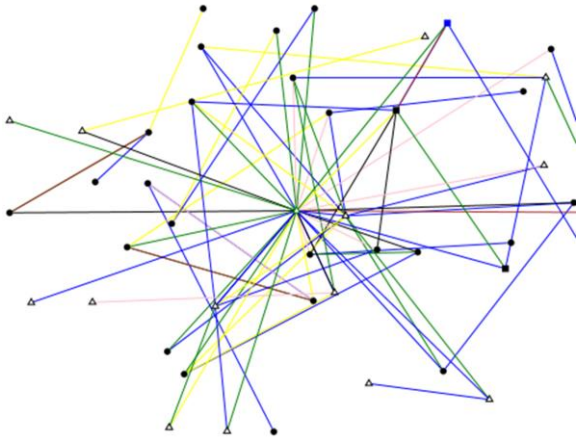


Figure 6I: Socio-gram of Beekeepers in Ibadan zone I & II

Socio-Centric Network Structures Analysis

Table 2: Social network centrality measures of identified network stars across FEBKAN zones

Zone/Vertex	Degree	In-Degree	Out-Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality	Clustering Coefficient
Ibadan I & II*	33	28	5	1.000	1.364	0.594	0.032
Ibarapa	16	12	4	0.234	1.607	0.376	0.135
Ogbomoso	19	14	5	1.000	1.636	0.531	0.090
Oke-Ogun Zone I	44	39	5	1.000	1.506	0.596	0.024
Oke-Ogun Zone II	36	31	5	1.000	1.542	0.513	0.046
Oyo	37	32	5	1.000	1.135	0.486	0.057

Ibadan I & II*: Although they are distinct zones but they are doing things together.

Based on the centrality measures of the beekeepers' network in the study area, the Table revealed the degree and in-degree of the beekeepers. It was revealed that Oke-Ogun Zone I has the highest degree (44) and in-degree (39) this is followed by Oyo which has (37 and 32) and Oke-Ogun Zone II (36 and 31). This indicates that network stars in these zones were well connected and they were the mostly consulted for beekeeping information. The result indicated that the information flow was largely demand-driven, that is, most members were seeking advice from the identified individuals instead of information flowing evenly throughout the network. The finding indicate that the structure of the association is a centralized information network where a few notable persons serve as the principal repositories of knowledge to other members of the group. The Table further revealed out-degree information of the group members. As indicated on the Table majority of the zone has out-degree of 5 which is the maximum number of persons they were asked to list. Since that was the methodological approach used, this creates constraint for further analysis of the result.

In addition, the results revealed that five zones have betweenness of 1.000 expect Ibarapa which has 0.234. The result indicated that the identified network stars in Ibadan I & II, Ogbomoso, Oke-Ogun I, Oke-Ogun II, and Oyo function as important intermediaries through whom information passes. They were likely to connect otherwise separate groups of beekeepers, facilitating coordination and dissemination of knowledge. However, the lower betweenness observed in Ibarapa indicate that information exchange is less dependent on a single person (bridging actor) and may instead occur through multiple alternative pathways or a more distributed communication structure. Similarly, a non-normalized closeness values indicated Ogbomoso and Ibarapa had comparatively high closeness values. It shows that the network stars can potentially reach other members of the group through shorter communication paths and can slower dissemination of information across the network. This is in respect of speed of diffusion of information among the group members.

Furthermore, The Table indicated the eigenvector values across the State, Oke-Ogun I (0.596), Ibadan I & II (0.594), Ogbomoso (0.531). The values show that the opinion leaders were connected not only to many people in the network, they were connected to other well connected people in the group. That is, these leaders occupy influential positions within influential circles, making them particularly suitable as entry points for extension programmes, innovation dissemination, and policy interventions. The results of the

clustering co-efficient indicated that the network was leader-centered instead of group centered. The implication is that if the opinion leader becomes inactive, retires, or leaves the association, communication could weaken considerably because few alternative peer-to-peer connections exist.

Based on these results, the centrality measures indicate that information exchange within the FEBKAN zonal networks is highly centralized around a few influential beekeepers. High in-degree and eigenvector centrality values indicate that these individuals were widely recognised as trusted sources of beekeeping information and technical advice, while high betweenness values indicate that they also serve as key intermediaries linking different segments of the network together. The consistently low clustering coefficients across all zones revealed that communication is largely mediated through these central actors rather than occurring within tightly interconnected peer groups. Consequently, the efficiency and resilience of information dissemination within the network depend largely on a small number of opinion leaders, underscoring the importance of engaging these individuals in extension service delivery, training programmes, and innovation dissemination. More so, strengthening peer-to-peer interactions would enhance network resilience by reducing reliance on a few highly central actors.

Objective 3: identify dominant information topics exchanged within beekeeper networks

Table 3: Identification of Dominant Information Topics Exchanged within Beekeeper Networks among the Respondents

Code	Information focus	Frequency	%
Black	Association matters	44	10.0
Blue	Security	192	43.7
Brown	Training and Induction	12	2.8
Green	Management practices	113	25.7
Pink	Finance	24	5.4
Yellow	Harvesting and Marketing	54	12.3

Source: Field Survey (Multiple choices were recorded)

Table 3 shows that 43.7% of the information exchanged among respondents focused on security issues, particularly hive theft and vandalization (Security), making it the most preponderant discussion topic within the beekeeping network. This was followed by beekeeping management practices (25.7%), harvesting and marketing (12.3%), association matters (10.0%), finance (5.4%), and training and induction (2.8%). The predominance of security-related discussions indicates that protecting apiaries and beekeeping equipment constitutes the most pressing challenge confronting beekeepers in the study area.

The high proportion of security-related interactions is attributable to the recurrent incidents of hive theft and vandalisation reported by respondents during the field survey. Respondents consistently identified insecurity as a persistent challenge affecting their beekeeping enterprises. Several participants provided photographic and video evidence of cattle destroying apiaries during grazing activities. Respondents further explained that apiaries located in the wide or farms and other remote areas are vulnerable because cattle herders often graze across extensive areas, making it difficult to conceal hive locations. In some cases, discovered hives were reportedly harvested using fire rather than conventional smoking techniques, resulting in damage to hives, bee colonies, and surrounding vegetation. The finding is in line with the observation of Okere et al. (2023) where

theft was identified as one of the challenges of beekeeping in Nigeria. Ijigbade et al. (2026) also mentioned human disturbance as one of the factors affecting honey production in Nigeria. similarly, Chiemela et al (2022) observed that theft and vandalism are part of challenges confronting beekeeping in Nigeria.

These security challenges substantially influenced patterns of information exchange within the network. Rather than discussing routine production practices, beekeepers frequently consulted one another to seek advice, share experiences, and develop collective strategies for preventing theft and reducing vandalisation. The field discussions revealed several adaptive measures, including constructing hives with metal or brick materials instead of wood, organizing joint security arrangements among neighbouring beekeepers, and relocating apiaries to protected government reserve areas where access by unauthorized persons and grazing livestock could be better controlled. The prominence of security as an information domain therefore demonstrates that communication within the network was largely driven by the need to collectively respond to a common production risk. This finding suggests that information exchange among beekeepers extends beyond technical production knowledge to include collaborative problem-solving and adaptive responses to local environmental and security challenges. The finding is similar to the observation of Hendricks and Masehela (2024) where it was mentioned that daily conversation of beekeepers in South Africa via WhatsApp and Google groups revolve around theft and vandalism. Engebretson et al. (2022) also affirmed that association remains a trusted network of exchanging information on beekeeping management practices among the beekeepers.

Table 4: Socio-centric of the beekeepers' association

Metrics	Values					
Graph Type	**Directed**					
Zones	**Oke-Ogun I**	**Oke-Ogun II**	**Ogbomoso**	**Ibarapa**	**Oyo**	**Ibadan**
Unique Edges	174	114	42	59	100	79
Duplicate	2	10	4	4	0	4
Total Edges	176	124	46	63	100	83
Self-loops	0	0	0	0	0	0
Vertices	48	42	25	25	48	45
Graph Density	0.0210	0.0527	0.0909	0.0775	0.0711	0.0419
Node XL version	1.0.1.92					

From the Table, the graph type was shown to be directed. This was because information flow involves source and receiver, information originates from the source and transfer through information channel to the receivers. Also, the unique edges of the respondents were indicated, which showed that 'Oke-Ogun zone I' had more of all the unique edges with 174 individuals, followed by Oke-Ogun zone II and Oyo zone with 114 and 100 unique edges, respectively.

The Table further revealed that all the zones had 0 (zero) self-loops, which implies that none of the edges had a vertex connected to itself, that is, none of the respondents was connected back to themselves. The situation can occur if the respondent mentioned a similar name(s) to himself. Also, from the Table, the graph density, which was an indication of the interconnectedness of the respondents, was observed to be far from 1. This implies that, in all the zones, there is less interconnection among the respondents. Generally, according to the findings of Kamau et. al. (2018), the larger the network, the lower the density; this can be estimated using:

$$\text{Network Density} = \frac{No.of\ existing\ ties}{Total\ possible\ no.of\ ties}$$

The Table revealed that Ogbomoso zone density was the highest, though still low at 0.009 Researches have indicated that this value though low but it still within a normal value. It shows that the diversity of sources of information among the respondents is diverse. If the respondents were clustered together, it may lead to inbreeding, which is not good in the dynamic world of ideas (Kamau et. al., 2018).

Conclusion and Recommendations

Based on the findings of this research, it is concluded that beekeeping communication in the study area is characterised by a centralised but sparse network structure. Beekeepers' association remains the main source of information flow among the respondents and a small group of very influential network stars who serve as critical information bridges. While these leaders are essential for the survival of the current network, the low graph density across all zones suggests that the beekeepers utilised diverse sources of information which may foster benefit from widespread peer-to-peer knowledge and information sharing. More so, the prevalence of security concerns (theft and vandalization) as the dominant topic of discussion indicates a significant external threat that may be hindering the adoption of improved management practices. Thus, to transform the apiculture sector into a functional sector for poverty eradication and foreign exchange earnings, it is imperative to strengthen these social networks. Addressing the security issues associated with beekeeping will foster the sustainability of the sub-sector. More so, in designing extension activities aiming at beekeeping development, members of state executive council of the association should be involved trained as community extension workers.

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