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Network Structure and Distribution Mechanism of Superior Seeds through Social Network Analysis: The Perspective of Maize Farmers in Garut Regency

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ABSTRACT

Maize is a strategic agricultural commodity used both as a food source and as a major component of animal feed, making increased production increasingly important. One way to improve maize productivity is to use superior maize seeds. However, farmers' access to these seeds remains uneven due to constraints in the distribution system. This study analyzes the social network structure of the maize seed distribution system and identifies the key actors influencing farmers' access to seeds, information, and solutions. Using a Social Network Analysis (SNA) approach with an ego-network perspective, the study was conducted in two maize-producing sub-districts in Garut Regency and involved 100 farmers selected through stratified random sampling. Data were collected through questionnaires and analyzed using Gephi 0.10. The results show that the seed distribution network is direct, heterogeneous, and relatively sparse, with farmers connected mainly to specific central actors rather than through intermediary channels. Farm shops, fellow farmers, and government assistance programmes occupy dominant positions in the network, indicating the importance of market-based mechanisms, informal farmer networks, and state support in shaping seed access. In contrast, local institutional actors, particularly cooperatives and farmer groups, have not played an optimal role in the distribution network. These findings suggest that improving farmers' access to superior maize seeds requires strengthening local farmer institutions, increasing coordination among distribution actors, and reducing dependence on a limited number of dominant actors.

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1. Introduction

Maize is a strategic agricultural commodity because it has multiple functions in food, feed, and agricultural production systems. In addition to being used as a food source, maize is an important raw material for animal feed. The Ministry of Agriculture (2024) notes that maize is the dominant ingredient in animal feed, accounting for up to 40% of feed composition. This demand is also reflected in the fact that more than 50% of the total national maize requirement is supplied by the animal feed industry (Utomo, 2012). These conditions show that maize has strong market prospects and plays an important role in supporting food security and the livestock sector. Therefore, efforts to increase maize productivity are increasingly important.

One of the most rational strategies for increasing maize production is the use of superior maize varieties. This strategy is particularly relevant amid several constraints faced by the agricultural sector, including limited agricultural land, budget limitations, and climate uncertainty (Sejati, 2015). Superior seeds can help farmers improve productivity without necessarily expanding cultivated land. Therefore, the availability of and access to superior seeds are key factors in the success of maize farming. However, farmers' access to superior seeds remains uneven. Although the government has introduced various programmes to increase the use of high-yielding seeds, their adoption remains suboptimal and has not fully met farmers' cultivation needs (Directorate General of Food Crops, 2025).

Several factors hinder the use of superior seeds at the farmer level. Krisdiana (2014) found that farmers face obstacles related to the timeliness of seed availability, the suitability of seed varieties to local needs, the distance to distribution points, and the relatively high price of seeds. Similar constraints have also been reported in studies on farmers' decisions to use hybrid maize seeds, where seed access, price, suitability, and availability of supporting inputs influence adoption decisions (Permasih et al., 2014; Apriliana & Mustadjab, 2016). These findings indicate that the problem of superior seed use cannot be understood only from the perspective of seed production or farmers' willingness to adopt new varieties. It must also be examined through the distribution system that determines whether farmers can obtain suitable seeds at the right time, in the right quantity, and at an affordable price.

Garut Regency is one of the maize production centres in West Java Province. In 2025, maize kernel production in Garut Regency reached 458,686 tons (Garut Regency Agriculture Service, 2026). This production level demonstrates the important contribution of Garut Regency to maize supply in West Java. The region also has land potential and agroclimatic conditions suitable for maize cultivation (Zulfah et al., 2024). With this potential, Garut Regency has a strong opportunity to increase maize production and contribute more significantly to regional and national maize demand.

Despite this potential, Garut Regency still faces challenges in distributing high-quality seeds at the local level. Secondary data from the Garut Regency Agriculture Office indicate that the region currently lacks local seed breeders. This condition makes farmers dependent on seed supplies from outside the region and on government seed assistance. As a result, the use of high-quality seeds depends heavily on the smoothness and effectiveness of the seed distribution system. Alfons (2007) emphasizes that seed availability is a crucial element in supporting food security, while Gairhe et al. (2021) show that seed production and distribution systems play an

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important role in expanding the adoption of maize seed technologies. When seed distribution does not function optimally, farmers may experience delayed access, limited seed choices, or dependence on particular actors who control the flow of seeds and related information.

Seed distribution at the farmer level is not only a technical process involving the movement of seeds from producers to users, but also a social process. It is also a social process shaped by actors, relationships, information flows, and access mechanisms. Formal seed systems usually involve research institutions, seed producers, government agencies, farm shops, cooperatives, and other official distribution channels. However, smallholder farmers often rely not only on formal seed systems but also on informal systems, including seed exchange, seed loans, seed saving, and interpersonal networks among farmers (McGuire & Sperling, 2016; Hlatshwayo et al., 2021). Coomes et al. (2015) also show that farmer seed networks operate through exchange, gifting, and small-scale sales, while Joshi et al. (2012) argue that collaboration between formal and informal seed systems is important for maintaining seed availability and supporting agricultural innovation.

Therefore, understanding the distribution of superior maize seeds requires an analysis of the network of actors involved in farmers' access to them. Actors such as farm shops, extension workers, collectors, cooperatives, farmer groups, fellow farmers, and government assistance programmes may occupy different positions in the distribution system. Some actors may become central because many farmers depend on them, while others may play supporting or marginal roles. Extension workers, for example, may function as facilitators, advisors, and links between farmers and agricultural institutions (Sofia et al., 2022), while farmer groups can support interaction, information exchange, and technology dissemination among farmers (Nuryanti & Swastika, 2011). Cooperatives also have the potential to support farmers' economic access, although their role depends on farmers' perceptions and institutional performance (Koib & Simamora, 2022).

The positions of these actors can affect the flow of seeds, information, and support for problem-solving. Social networks influence how farmers obtain knowledge, exchange information, and make decisions regarding agricultural innovation (Haythornthwaite, 1996; Wu & Zhang, 2013). Farmers with broader and stronger networks tend to have better opportunities to access agricultural knowledge and resources than those with limited networks (Pratiwi & Suzuki, 2017). In this sense, access to superior seeds is shaped not only by the physical availability of seeds but also by the structure of farmers' social relationships with distribution actors.

Previous studies on superior maize seeds have largely focused on technical and socioeconomic aspects, including farmer knowledge, adoption decisions, input availability, and the effectiveness of government assistance programmes (Permasih et al., 2014; Gunawan et al., 2022; Nurtini et al., 2024). Studies have also shown that government seed assistance can improve farmers' access to superior seeds, although it may also create dependence when farmers rely too heavily on subsidized or assisted seed distribution (Hutagaol & Hartoyo, 2013; Ginting et al., 2020; Mayrowani, 2008; Ritonga & Kenedi, 2025). These studies have contributed to understanding why farmers adopt or do not adopt superior seeds. However, they provide a limited explanation of how farmers' social relationships with distribution actors shape access to seeds, information, and solutions within the local distribution system.

Social Network Analysis (SNA) offers a useful approach for examining these relationships. SNA enables the identification of key actors, relationship patterns, and network positions that influence farmers' access to superior seeds. In network analysis, relationships are understood through nodes and ties, where actors occupy different positions within a structure of interaction (Wasserman & Faust, 1994; Hanneman, 2001). Measures such as degree centrality, betweenness

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centrality, closeness centrality, eigenvector centrality, density, modularity, and path length can show which actors are most connected, which actors are influential, and how cohesive or fragmented the distribution network is (Borgatti, 2005; Alhajj & Rokne, 2018). An ego-network perspective is particularly relevant because it centres farmers in the analysis and examines their direct relationships with actors involved in seed access (Crossley et al., 2017; Geleta et al., 2023). This perspective helps explain how farmers perceive and experience access to seeds, information, and solutions within the local distribution system.

Based on this background, this study aims to analyze the social network structure of maize seed distribution in Garut Regency and identify the key actors that influence farmers' access to superior seeds. Using a cross-sectional design and a Social Network Analysis approach with an ego-network perspective, this study examines relationship patterns between farmers and distribution actors at the farm level. The study focuses on farmers' perceptions of actors who provide superior maize seeds, information, and solutions. By doing so, this research explains how local distribution networks operate in a region with limited local seed breeding capacity and dependence on external seed supplies and government assistance.

The findings are expected to contribute to the development of more targeted and sustainable seed distribution policies. By identifying dominant and marginal actors in the distribution network, this study provides insights into strengthening local farmer institutions, improving coordination among actors, and reducing dependence on a limited number of dominant actors. In practical terms, understanding the social network structure of superior seed distribution can support better planning of seed distribution systems and improve farmers' access to superior maize seeds in Garut Regency.

2. Literature Review

The distribution of superior maize seeds is an important part of the agricultural input system because it determines whether farmers can obtain seeds that meet their production needs. In formal seed systems, seed distribution generally begins with the production of core or breeder seeds by research institutions, followed by further multiplication by seed agencies, public institutions, and private seed producers. These seeds are then distributed through official channels such as agricultural input shops, cooperatives, seed producers, and government programmes before reaching farmers (Agricultural Research and Development Agency, 2015). This formal distribution system is expected to ensure seed availability, quality, and traceability, particularly for superior maize varieties.

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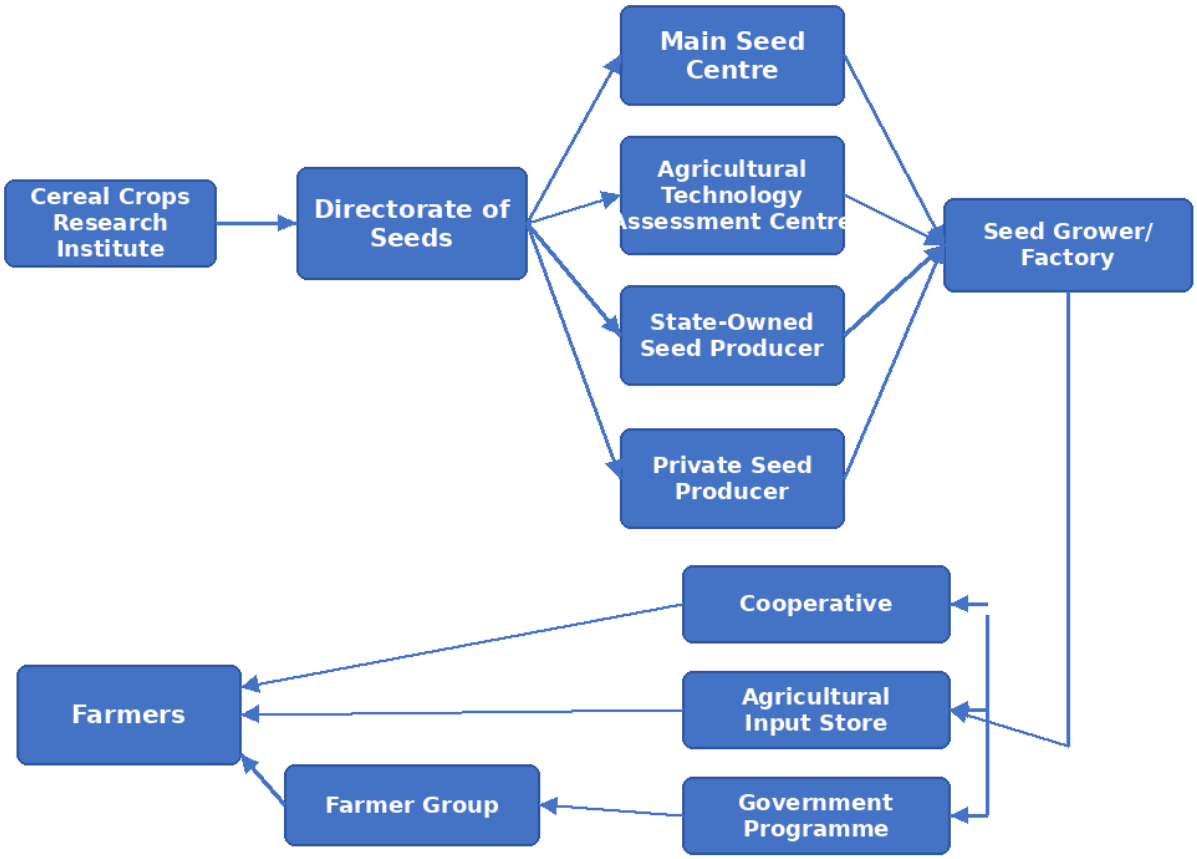

Figure 1. Formal Distribution Flowchart of Maize Seeds
Source: (Agricultural Research and Development Agency, 2015)

However, seed access among smallholder farmers is rarely limited to formal distribution channels. Farmers often obtain seeds through a combination of formal and informal systems. Formal systems include government seed assistance, purchases from farm shops, cooperatives, and other official distribution channels, while informal systems include seed saving, seed exchange, seed loans, and interpersonal relationships among farmers. Hlatshwayo et al. (2021) show that smallholder seed systems often depend on interactions between formal and farmer-based systems. Similarly, McGuire and Sperling (2016) argue that smallholder farmers use multiple seed channels depending on availability, affordability, trust, and local suitability. Coomes et al. (2015) also show that farmer seed networks operate through exchange, gifting, and small-scale sales, indicating that informal networks remain important in maintaining seed access at the farm level. Therefore, collaboration between formal and informal systems is needed to maintain seed availability and support farmers' access to appropriate seed varieties (Joshi et al., 2012).

An effective seed distribution system should deliver superior seeds to farmers, in accordance with the six rights: variety, quality, quantity, time, location, and price (Nugroho et al., 2018). This principle shows that distribution is not only concerned with moving seeds from producers to farmers, but also with ensuring that seeds are accessible and suitable for farmers' production conditions. Distribution is closely related to the roles of institutions and actors involved in the flow of goods, including agents, dealers, wholesalers, traders, retailers, and other local distribution actors (Lubis, 2004). In the context of maize seed distribution, actors such as farm shops, farmer groups, cooperatives, government assistance programmes, extension workers,

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collectors, and fellow farmers may influence farmers' access not only to seeds but also to information and problem-solving support related to seed use.

The role of these actors is important because seed access is shaped by social relationships as well as by physical availability. Farmers often rely on trusted actors when deciding where to obtain seeds, which varieties to use, and how to solve problems related to seed quality or availability. Farm shops may function as market-based access points, while extension workers may provide technical information and institutional linkages. Farmer groups may facilitate communication and collective access, whereas fellow farmers may provide informal information, practical experience, and seed exchange. McGuire and Sperling (2016) emphasize that farmers' seed access is shaped by diverse channels and social relationships, especially in smallholder farming contexts. This means the distribution of superior maize seeds must be understood as a network involving multiple actors with varying levels of influence.

Social networks provide a useful lens for understanding these relationships. A social network consists of actors and the ties that connect them, where the structure of these ties influences the flow of resources, information, and decisions. In agriculture, social networks can shape how farmers acquire knowledge, evaluate innovations, and decide whether to adopt new technologies or inputs. Haythornthwaite (1996) explains that social network analysis is useful for studying information exchange, while Wu and Zhang (2013) show that innovation diffusion among farmers is closely related to network building. Farmers with broader, stronger networks tend to have better access to agricultural knowledge and resources than those with limited networks (Pratiwi & Suzuki, 2017). Therefore, farmers' positions within networks can affect their ability to access seeds, information, and solutions.

In the context of farmer relationships, networks may include bonding and bridging forms of social capital. Bonding ties generally refer to close relationships among actors with similar social backgrounds, such as relationships among fellow farmers within a local community. Bridging ties connect farmers to wider actors, groups, or institutions, such as extension workers, farm shops, cooperatives, or government programmes. These different forms of ties can create different types of access. Bonding ties may support trust, mutual assistance, and informal exchange, while bridging ties may provide access to external information, institutional support, and market-based resources. Mutyebere et al. (2026) show that farmers' social networks can influence agricultural risk management and decision-making, thereby shaping farmers' responses to production challenges.

Previous studies have examined various aspects of the distribution and adoption of superior maize seeds. Some studies focus on farmers' knowledge and attitudes toward labelled or certified maize seeds (Nurtini et al., 2024), while others examine socioeconomic factors influencing farmers' decisions to use hybrid maize seeds (Permasih et al., 2014; Apriliana & Mustadjab, 2016). Studies on government seed assistance also show that assistance programmes can increase farmers' access to superior seeds, although they may also create dependence if farmers rely too heavily on government support (Hutagaol & Hartoyo, 2013; Ginting et al., 2020; Mayrowani, 2008; Ritonga & Kenedi, 2025). In another context, Gairhe et al. (2021) demonstrate that a well-functioning maize seed production and distribution system can support wider adoption of improved seed varieties. These studies are important, but they largely focus on adoption, programme effectiveness, and distribution performance rather than the structure of social relationships through which farmers access seeds.

Research on agricultural communication and social networks suggests that farmers' access to technology and innovation is influenced by the actors with whom they interact. Hertanto et al. (2016), for example, show that communication networks influence farmers' roles in the

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application of agricultural technology. Pratiwi and Suzuki (2017) also show that farmers' social networks affect knowledge acquisition in rural Indonesia. These findings suggest that access to agricultural inputs and innovation is not only determined by individual characteristics or institutional programmes, but also by the structure of relationships among farmers and related actors. However, studies that specifically examine how farmers' ego-networks shape access to superior maize seeds remain limited, especially in local contexts where farmers depend on external seed supplies and government assistance.

Social Network Analysis (SNA) is therefore relevant for examining the structure of relationships in maize seed distribution. SNA views social relations as a structure consisting of nodes and ties, where nodes represent actors and ties represent relationships between actors (Wasserman & Faust, 1994; Hanneman, 2001). Through SNA, researchers can identify central actors, relationship patterns, and the extent to which certain actors dominate, connect, or mediate access within a network. Centrality measures such as degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality help explain the position and influence of actors within the network (Borgatti, 2005; Alhajj & Rokne, 2018). These measures help identify which actors are most connected, strategically positioned, and influential because of their connections to other important actors. In addition, network-level measures such as density, modularity, and average path length can help explain whether a distribution network is cohesive, clustered, fragmented, or dependent on particular actors.

The ego-network approach is particularly suitable for this study because it places farmers as the central actors and examines their direct relationships with other actors involved in seed access. Ego-network analysis can reveal how farmers perceive and experience access to seeds, information, and solutions through their immediate relationships. Crossley et al. (2017) explain that ego-networks are useful for understanding how personal networks influence access to resources, opportunities, and social support. Geleta et al. (2023) also show that egocentric network measures can help understand individual preferences and decision-making in resource-related contexts. In this study, the ego-network approach is used to map farmers' relationships with distribution actors and to identify which actors play central roles in shaping access to superior maize seeds.

Based on this literature, the distribution of superior maize seeds can be understood as a networked process involving formal channels, informal relationships, and institutional actors. The central issue is not only whether superior seeds are available, but also how farmers are connected to actors who provide seeds, information, and solutions. By applying SNA with an ego-network perspective, this study seeks to fill the gap in previous research by examining the structure of farmer relationships in the maize seed distribution system and identifying key actors influencing access to superior seeds in Garut Regency.

3. Research Methodology

This study was conducted in Garut Regency, one of the maize production centres in West Java Province. The research focused on two sub-districts, namely Karangpawitan and Balubur Limbangan. These locations were selected because they are among the main maize-producing areas in Garut Regency (Garut Regency Agriculture Service, 2026).

The study population consisted of maize farmers in Garut Regency, specifically from Balubur Limbangan and Karangpawitan sub-districts. The farmer populations in these two sub-districts were 6,087 and 3,418, respectively. The sample size was determined using the Yamane (1967) formula with a 10% margin of error, resulting in 99 respondents. This number was then rounded to 100 maize farmers. The sampling technique used was stratified random sampling, with

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respondents distributed proportionally across the two sub-districts. Balubur Limbangan consisted of nine maize-producing villages, while Karangpawitan consisted of seven maize-producing villages. At the village level, respondents were selected using simple random sampling.

This study used both primary and secondary data. Primary data were collected through questionnaires administered to maize farmers. The questionnaire was designed to identify farmers' relationships with actors involved in access to superior maize seeds, including seed sources, information sources, and solutions related to seed use. Secondary data were obtained from the Ministry of Agriculture, the Central Statistics Agency (BPS), the Garut Regency Agriculture Service, and other relevant institutions.

The network structure and distribution mechanism of superior maize seeds were analyzed using Social Network Analysis (SNA). SNA is used to examine patterns of relationships among actors within a network. In SNA, social relationships consist of nodes and ties, where nodes represent actors or individuals, while ties represent relationships, links, or connections between actors (Oktora & Alamsyah, 2014). In this study, the nodes consisted of maize farmers and distribution actors, while the ties represented farmers' relationships with actors who provided access to seeds, information, and solutions. The distribution actors included farm shops, extension workers, collectors, cooperatives, farmer groups, fellow farmers, and government assistance programmes. The data were processed and visualized using Gephi 0.10.

Following Wasserman and Faust (1994), SNA enables researchers to identify key actors in a network through centrality measures. This study used degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality to examine the position and influence of actors in the superior maize seed distribution network.

Degree centrality measures the number of ties an actor has in the network. Actors with higher degree centrality have more direct connections and can be understood as more central in farmers' access to seeds, information, or solutions. In this study, degree centrality was used to identify actors most frequently connected to farmers in the distribution network.

Betweenness centrality measures the extent to which an actor acts as an intermediary or bridge in the network. An actor with high betweenness centrality lies on many shortest paths between other actors and may control or facilitate the flow of resources and information. This measure was used to examine whether certain actors served as intermediaries in farmers' access to superior maize seeds.

Closeness centrality measures how close an actor is to other actors in the network based on geodesic distance. Actors with higher closeness centrality can reach other actors more quickly and may have greater potential to access or distribute information efficiently (Alhajj & Rokne, 2018).

Eigenvector centrality measures the importance of an actor not only by the number of connections but also by the quality or importance of the actors to whom it is connected. Actors with high eigenvector centrality are connected to other influential actors and therefore occupy a more influential position in the network (Alhajj & Rokne, 2018).

In addition to centrality measures, this study also used structural measures, including modularity, density, and average path length, to understand the overall pattern of the distribution network. Modularity was used to identify clusters or groups within the network. Density was used to assess the level of connectedness among actors in the network, while average path length measured the average distance between actors. These measures helped explain whether the seed distribution network was cohesive, fragmented, clustered, or dependent on particular actors.

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Relational data were collected by asking respondents to identify the actors involved in their access to superior maize seeds. Respondents were asked to select and rank actors based on the intensity and importance of their relationships in three dimensions: sources of seeds, sources of information about seeds, and sources of solutions related to seed problems. Respondents were also asked to identify the main actor they relied on for seed access. The selected actors were then converted into network data and assigned weights reflecting their importance in farmers' access to superior maize seeds.

The weighting system was used to distinguish the strength and importance of each relationship. Actors mentioned as sources of seeds, information, or solutions were assigned a weight of 1. Actors identified as more important or more frequently relied upon were assigned a higher weight. Actors identified as the main source of access to superior seeds were assigned the highest weight. Through this weighting process, the study distinguished between actors who were only occasionally connected to farmers and those who played a more central role in shaping seed access. The resulting network was then analyzed using Gephi 0.10 to identify central actors, relationship patterns, clusters, and the overall structure of the maize seed distribution network in Garut Regency.

4. Results and Discussion

Farmers' behaviour and choices in accessing superior maize seeds are shaped not only by the physical availability of seeds but also by the social relationships through which they obtain seeds, information, and solutions. In this study, Social Network Analysis (SNA) is used to examine the structure of these relationships by focusing on farmers' ego-networks. In an ego-network approach, farmers are positioned as the ego, while the actors connected to them are treated as alters. These actors include farm shops, extension workers, collectors, cooperatives, farmer groups, fellow farmers, and government assistance programmes. The resulting network illustrates how farmers perceive and experience access to superior maize seeds through direct relationships with these actors.

An egocentric network consists of nodes and ties, where nodes represent actors and ties represent relationships between them. In this study, nodes consist of maize farmers and distribution actors, while ties represent farmers' relationships with actors who provide access to seeds, information, or solutions. The position and influence of actors in the network are examined using degree centrality, closeness centrality, betweenness centrality, eigenvector centrality, and PageRank. These measures help identify which actors are most frequently connected to farmers and which actors occupy important positions in the distribution network (Geleta et al., 2023).

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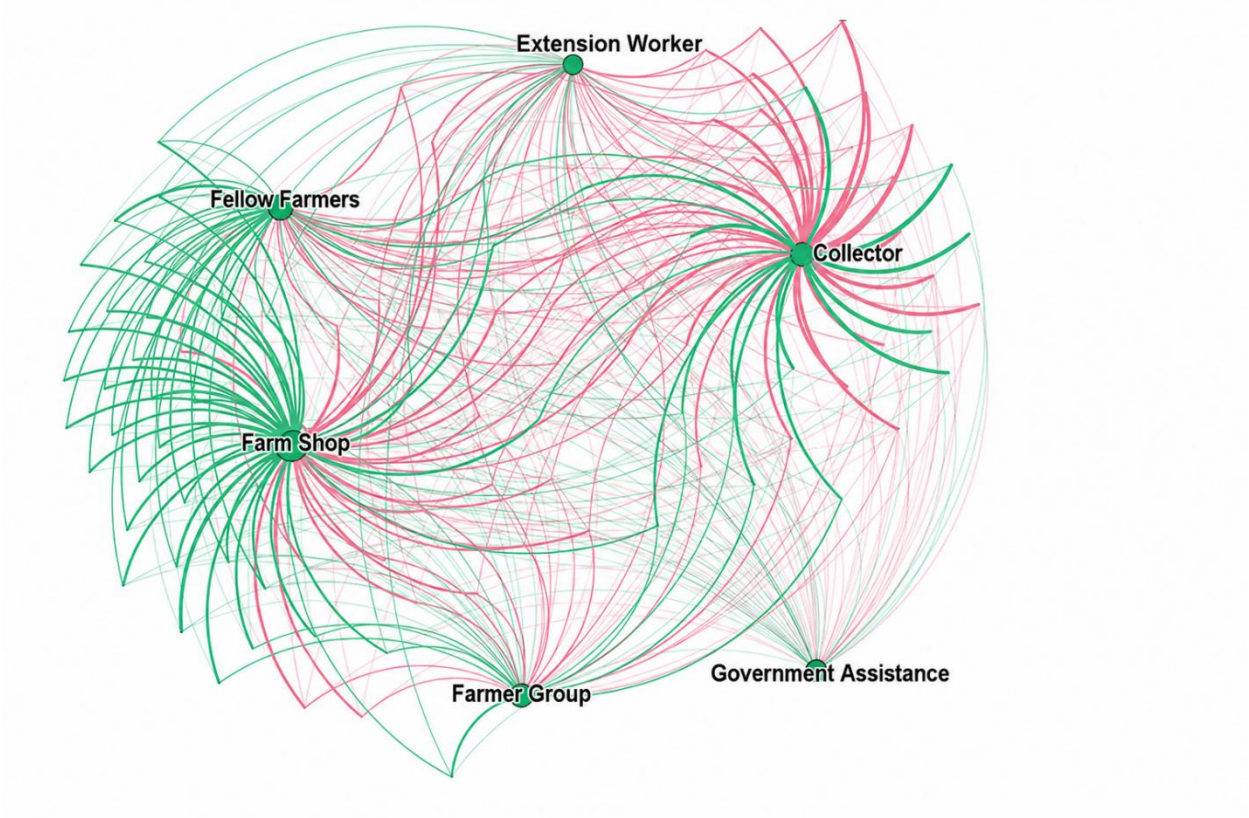

Figure 2. Degree Centrality of the Superior Maize Seed Distribution Network
Source: Processed Primary Data, 2026

The network visualization in Figure 2, generated using Gephi 0.10, shows a two-mode network structure. A two-mode network consists of two types of nodes within a single relational system (Akbar et al., 2022). In this study, the first type of node consists of farmers as seed users, while the second type consists of distribution actors as sources of seeds, information, or solutions. The ties in the network represent direct relationships between farmers and these distribution actors. Because the data were collected from farmers' perceptions of actors involved in seed access, the network does not depict direct ties among farmers or among distribution actors.

The visualization indicates a direct and heterogeneous access structure. Farmers are connected directly to selected distribution actors, forming a pattern in which several actors occupy more central positions than others. This pattern shows that seed access at the farmer level does not occur through a single linear channel. Instead, farmers rely on multiple access routes involving market actors, informal farmer-based networks, and institutional support. This finding is consistent with the argument that farmers use diverse seed channels depending on availability, trust, affordability, and local suitability (McGuire & Sperling, 2016). It also supports the view that real-world networks are often heterogeneous, with some nodes having more connections and greater prominence than others (Borgatti, 2005; Newman, 2018).

The larger nodes in Figure 2 indicate actors with higher degree centrality. These actors are more frequently mentioned by farmers as sources of seeds, information, or solutions. The centrality results obtained from Gephi 0.10 are presented in Table 1.

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Table 1. Centrality Measures of Actors in the Superior Maize Seed Distribution Network

Actor	Degree	Closeness	Betweness	Eigenvector	PageRank
Farm Shops	91	0	0	0,483393	0,100723
Extension Workers	72	0	0	0,407533	0,073434
Collectors	63	0	0	0,356281	0,064952
Cooperatives	1	0	0	0	0,005948
Farmers Groups	61	0	0	0,330315	0,066501
Fellow Farmers	82	0	0	0,434464	0,092094
Government Assistance Programmes	74	0	0	0,418817	0,075351

Source: Processed Primary Data, 2026

Table 1 shows that farm shops have the highest degree centrality score, at 91. This indicates that farm shops are the most frequently connected actors in farmers' access to superior maize seeds. Their dominant position suggests that market-based distribution mechanisms play a central role in the seed distribution system at the research site. Farm shops serve not only as physical providers of seeds but also as access points where farmers obtain information and practical solutions for seed use. This finding is consistent with Ramaswami et al. (2009), who argue that agricultural input retailers can act as important intermediaries between seed producers and farmers by understanding farmers' responses, estimating seed demand, and influencing farmers' preferences. Rutsaert and Donovan (2020) also show that farmers connected to agro-dealers or input shops tend to have better access to information about improved maize seed varieties.

Fellow farmers also occupy a prominent position, with a degree centrality score of 82. This indicates that many respondents perceive other farmers as important sources of seeds, information, or solutions. At the research site, this role is reflected in practices such as seed borrowing, seed exchange, and the sharing of experience related to seed quality, planting decisions, and seed-related problems. This finding demonstrates that farmers are not merely seed users but also part of an informal seed access system. McGuire and Sperling (2016) emphasize that smallholder farmers often rely on farmer-based networks when formal seed systems are limited or less responsive to local needs. Coomes et al. (2015) also show that farmer seed networks operate through exchange, gifting, and small-scale sales. However, because "fellow farmers" were treated in this study as an actor category rather than as individually identified farmer nodes, this result should be interpreted as the perceived importance of informal farmer-based networks, not as a detailed structural measurement of horizontal farmer-to-farmer ties.

Government assistance programmes also show a high degree of centrality score, with a value of 74. This indicates that government seed assistance remains an important channel for farmers' access to superior maize seeds. The role of government assistance is particularly relevant for farmers who face economic constraints or limited market access. Seed assistance programmes can reduce financial barriers and help farmers obtain superior seeds that may otherwise be difficult to access. Previous studies have shown that government seed assistance can improve farmers' access to superior seeds and support agricultural productivity (Hutagaol & Hartoyo, 2013; Ginting et al., 2020; Ritonga & Kenedi, 2025). Nevertheless, dependence on government seed assistance may also create vulnerability if farmers rely too heavily on subsidized or externally provided seeds. Mayrowani (2008) warns that seed assistance programmes may create

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dependence if not accompanied by efforts to strengthen local seed systems and farmer institutions.

The eigenvector centrality results further support the importance of these dominant actors. Eigenvector centrality measures an actor's influence not only by the number of connections it has but also by the importance of the actors to which it is connected. Actors with high eigenvector centrality are therefore considered influential because they are connected to other prominent nodes in the network (Andiani et al., 2025). Farm shops have the highest eigenvector value at 0.483393, followed by fellow farmers at 0.434464 and government assistance programmes at 0.418817. These results confirm that a combination of market-based actors, informal farmer networks, and state-supported distribution channels shapes the dominant structure of seed access in Garut Regency.

Other actors, such as extension workers, collectors, and farmer groups, occupy intermediate positions in the network. Extension workers have an eigenvector centrality value of 0.407533, indicating that they remain influential in the distribution network. Their role is important because they may connect farmers to technical information, institutional programmes, and agricultural guidance. Sofia et al. (2022) explain that extension workers act as guides, consultants, facilitators, and links between farmers and government institutions. However, their degree of centrality is lower than that of farm shops, fellow farmers, and government assistance programmes, suggesting that extension workers are not the primary access point for high-quality maize seeds, although they still provide information and support.

Collectors have a degree score of 63 and an eigenvector centrality value of 0.356281. This suggests that collectors are involved in the network but do not occupy the most central position in seed access. Their role may be more related to local agricultural transactions and farmer interactions than to formal seed distribution. Farmer groups also show a moderate level of involvement, with a degree score of 61 and an eigenvector value of 0.330315. This indicates that farmer groups still serve as spaces for interaction and information exchange, but they have not become the dominant channel for distributing superior maize seed. This finding is consistent with Nuryanti and Swastika (2011), who note that farmer groups can support technology dissemination and collective learning, although their effectiveness depends on institutional capacity and active participation.

In contrast, cooperatives occupy the weakest position in the network. Cooperatives have a degree score of only 1 and an eigenvector centrality value of 0.000000. This indicates that cooperatives have not played a significant role in farmers' access to superior maize seeds at the research location. Their weak position suggests that the potential function of cooperatives as farmer economic institutions has not been fully realized in the local seed distribution system. Koib and Simamora (2022) emphasize that agricultural cooperatives can support farmers' economic activities, but their effectiveness depends on farmers' trust, institutional performance, and relevance to farmers' needs.

The closeness, centrality, and betweenness centrality values in Table 3 are 0 for all actors. These values should not be interpreted as meaning that the actors have no practical role in the distribution system. Rather, they reflect the dataset's structure and the network type constructed in this study. The network records direct ties between farmers and distribution actors, but it does not map direct ties among farmers or among distribution actors. Therefore, the network does not show intermediary paths between actors. As a result, betweenness and closeness centrality are less informative for this particular network structure. For this reason, the interpretation of actor dominance in this study focuses mainly on degree centrality, eigenvector centrality, and PageRank.

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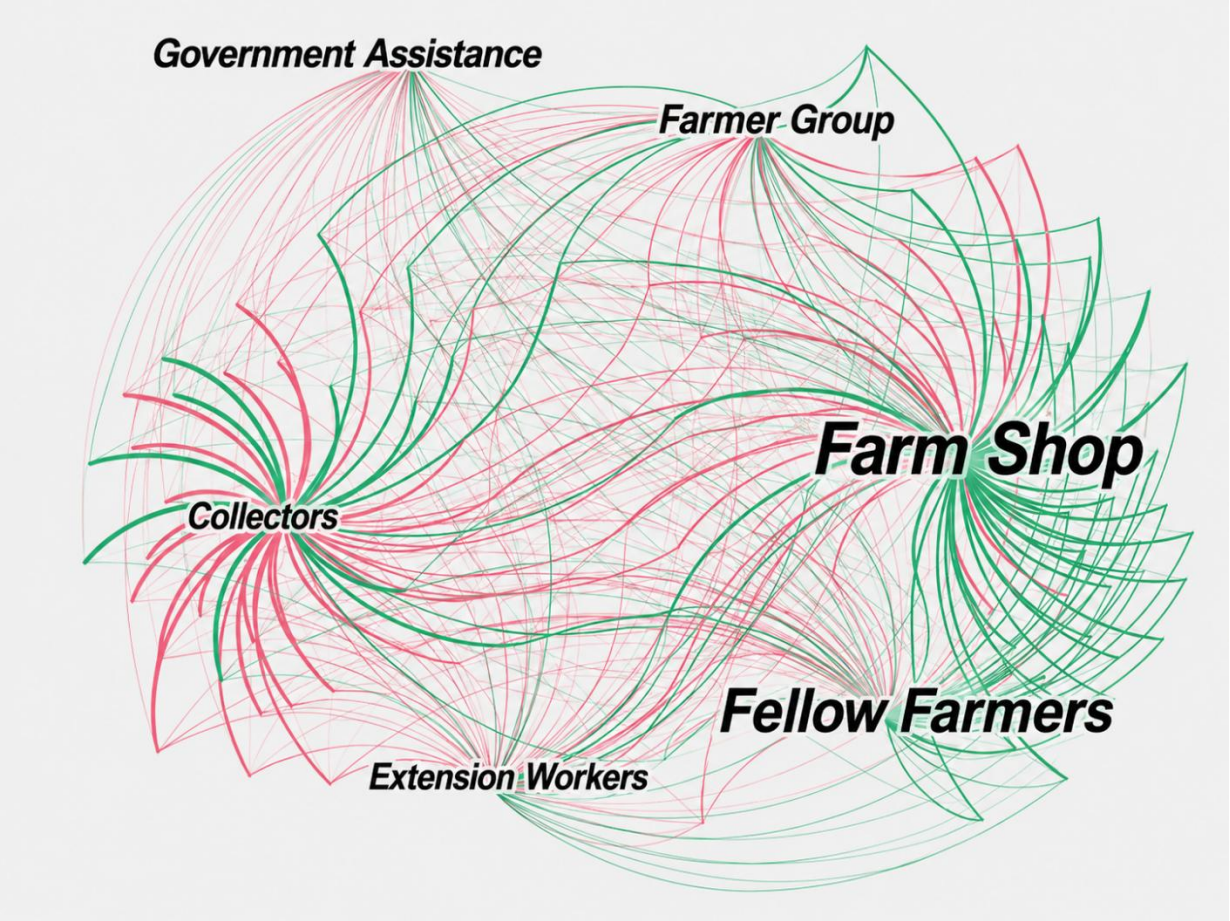

Figure 3. PageRank Centrality of Distribution Actors
Source: Processed Primary Data, 2026

PageRank provides another perspective on the relative prominence of actors in the seed distribution network. In this two-mode network, PageRank should be interpreted as the relative importance of distribution actors based on the number and weight of farmer nominations directed to them, rather than as evidence of direct actor-to-actor influence. The PageRank results show that farm shops, fellow farmers, and government assistance programmes have the highest values compared with other actors. Farm shops have the highest PageRank value at 0.100723, followed by fellow farmers at 0.092094 and government assistance programmes at 0.075351. These results reinforce the degree and eigenvector centrality findings, showing that farmers' access to superior maize seeds is concentrated around market actors, informal farmer networks, and government-supported channels.

The high PageRank value of farm shops confirms their role as strategic access points in the seed distribution network. Farmers rely on these actors not only to purchase seeds but also to obtain information about seed varieties and practical responses to seed-related problems. The high PageRank of fellow farmers also indicates that farmer-based informal networks remain important in supporting seed access, especially when formal access is limited, delayed, or perceived as less responsive to farmers' immediate needs. Meanwhile, the relatively high PageRank of government assistance programmes indicates that state-supported distribution remains an important mechanism for facilitating access, particularly for farmers with limited capacity to purchase seeds independently.

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The centrality and PageRank results indicate that the seed distribution mechanism at the farmer level is shaped mainly by three access routes: market-based access through farm shops, informal access through fellow farmers, and institutional access through government assistance programmes. Local institutions such as farmer groups and cooperatives have not yet become the main channels of distribution. This indicates that local institutional capacity remains limited in supporting a more integrated and independent seed distribution system.

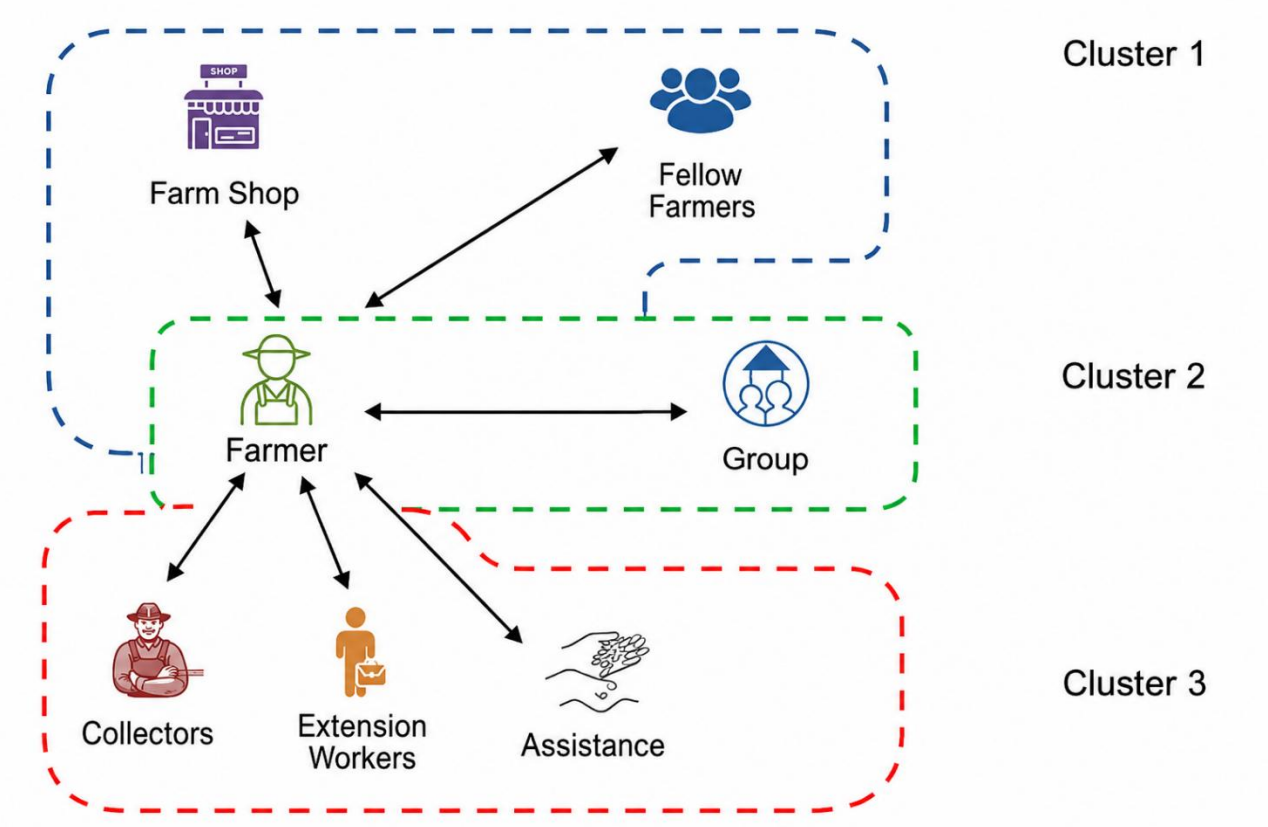

Figure 4. Modularity-Based Clusters in the Superior Maize Seed Distribution Network
Source: Processed Primary Data, 2026

The modularity results indicate the presence of three clusters within the superior maize seed distribution network in Garut Regency. These clusters suggest that farmers do not rely on a single distribution mechanism. Instead, different groups of farmers are connected to different sets of actors. One cluster is associated mainly with market-based and informal farmer networks, another with farmer-group-related access, and another with government- or assistance-based access. These clusters show that seed access is differentiated across the farmer network and that farmers combine different routes depending on their relationships with available actors.

The presence of these clusters supports the finding that the seed distribution system is heterogeneous. Farmers are not connected to a single dominant actor, but to several actor groups that play different roles. Market actors provide direct seed access, fellow farmers provide informal support and exchange, while government assistance programmes provide institutional support. However, the weaker position of farmer groups and cooperatives suggests that local institutions have not yet functioned as strong coordinating mechanisms across these different access routes. This condition may limit the potential for a more cohesive and integrated seed distribution system.

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The overall network has a density of 0.039, indicating it is sparse and has low cohesion. A low density value suggests that the relationships between farmers and distribution actors are not broadly interconnected across the network. This condition is partly related to the study's ego-network design, in which farmers identified actors involved in their own access to seeds, information, and solutions. In addition, the category of fellow farmers was treated as a general actor category rather than as individually identified farmer nodes. Therefore, the network does not fully capture detailed horizontal relationships among farmers.

A path length of 1 indicates that farmers' access to seeds occurs through direct relationships with specific actors rather than through intermediary chains. This finding is consistent with the zero values of betweenness and closeness centrality, which reflect the direct farmer–actor structure of the data. The short path length suggests that farmers generally access seeds, information, and solutions directly from actors they already know or rely upon. However, it also indicates that the network does not capture more complex interaction pathways among distribution actors. As a result, the network should be interpreted as a map of farmers' perceived access relationships rather than as a complete map of the entire maize seed supply chain.

The findings show that farmers' access to superior maize seeds in Garut Regency is shaped by a direct, sparse, and heterogeneous network. Farm shops, fellow farmers, and government assistance programmes are the most dominant actors, while farmer groups, extension workers, and collectors occupy intermediate positions. Cooperatives remain marginal in the distribution network. These results indicate that seed distribution at the farmer level is still strongly influenced by market mechanisms, informal farmer networks, and government assistance, while local farmer institutions have not yet played an optimal coordinating role. Strengthening farmer groups and cooperatives, improving coordination among distribution actors, and reducing dependence on a limited number of dominant actors are therefore important steps toward developing a more integrated and resilient seed distribution system.

5. Conclusion

Farmers' access to superior maize seeds in Garut Regency is shaped not only by the physical availability of seeds but also by the social network structure that connects farmers with actors in the seed distribution system. The ego-network analysis shows that farmers are directly connected to several key actors, particularly farm shops, fellow farmers, and government assistance programmes. These actors occupy dominant positions in providing seeds, information, and solutions related to seed access.

The findings indicate that superior maize seed distribution at the farmer level is mainly driven by market-based access through farm shops, informal farmer-based networks, and government assistance. In contrast, local institutions such as farmer groups and cooperatives have not yet played an optimal role as primary channels or coordinating actors in the distribution network. The low density and direct structure of the network also indicate limited interaction among actors, suggesting that the potential for broader collaboration and greater distribution efficiency has not been fully realized.

Although farmers' social networks play an important role in supporting seed access, the network structure also reflects dependence on a limited number of dominant actors. Therefore, strengthening local farmer institutions, improving coordination among distribution actors, and enhancing the role of farmer groups and cooperatives are necessary to develop a more integrated and resilient seed distribution system. These efforts are important for reducing excessive dependence on market actors and government assistance while improving farmers' sustainable access to high-quality maize seeds in Garut Regency.

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This study has several limitations. First, the analysis was based on an ego-network approach that captured farmers' direct relationships with distribution actors, but did not map the full structure of relationships among farmers, among distribution actors, or between formal institutions within the broader seed supply chain. Second, some actors, such as fellow farmers, were treated as general actor categories rather than as individually identified nodes. As a result, the study could not fully capture the detailed structure of horizontal farmer-to-farmer relationships. Third, the study used cross-sectional data, so it could not explain how seed access networks change over time, particularly across planting seasons, market fluctuations, or changes in government assistance programmes.

Future research should examine the maize seed distribution network using a more complete whole-network design that includes farmers, seed retailers, farmer groups, cooperatives, extension workers, government agencies, seed producers, and other relevant actors as distinct nodes. Further studies should also identify individual farmer-to-farmer ties to understand better informal seed exchange, trust, information diffusion, and mutual assistance within farming communities. Longitudinal research is also needed to examine how seed access networks evolve and how changes in policy, market availability, and local institutional capacity affect farmers' access to superior maize seeds.

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7. Declaration of Conflicting Interests

The authors declare that there is no conflict of interest regarding the research, authorship, and publication of this article.

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