

## Trust networks and agroclimatic risk in agricultural technical assistance, Colombia

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### Abstract

The objective of this research was to analyze the changes in the networks of technical trust of agricultural technical assistants (ATA), after a process of management and diffusion of a culture of agroclimatic risk over a period of two years in the departments of Cundinamarca, La Guajira and Valle del Cauca, Colombia. Interviews with ATAs were conducted in two moments of observation: at the beginning (2015) and at the end of the intervention of the agroclimatic adaptation and prevention models project (2017). The social network analysis was used as an analysis and an intervention tool, this permitted to identify the structure of the network and the actors with greatest coverage of information diffusion in the departments. The intervention of the MAPA project led to structural changes in the networks of technical trust of the ATAs and their perception of the importance of the agroclimatic risk issue in the provision of extension services. In Cundinamarca and La Guajira, the ATAs decreased the size of their network ( $p < 0.05$ ), however, the intermediation indicator increased significantly ( $p < 0.05$ ). It is concluded that, by intervening in the trust networks of the agricultural technical assistants through the design of a communicative strategy and the identification of key actors to disseminate the issue of agroclimatic risk, a greater linkage, access, exchange and scope of information was favored.

**Keywords:** adaptation to climate change, diffusion of information, management of knowledge.

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## Introduction

The alteration of climatic patterns undoubtedly affects agricultural production systems (Vergara *et al.*, 2014). In Colombia, the climatic phenomenon of La Niña during 2010 caused losses in the agricultural sector that reached 387.5 million pesos in the case of transient crops, for permanent crops the losses were estimated at 306 million pesos, in livestock they were 24 million pesos in meat production, and milk collection fell between 25 and 30%, the reduction was estimated at 400 liters not collected per day, and in poultry farming the losses were 2.4 million pesos including the value of dead birds (CEPAL, 2012).

In addition, climate scenarios for 2030 indicate a general increase in temperature across the country (with greater intensity in the south), which could cause water shortages for agricultural production (CIMMYT, 2019). In this regard, the Adaptation Fund was created in Colombia in 2010, with the aim of promoting solutions for those directly affected by the La Niña climate phenomenon and providing responses of adaptation to extreme weather events in the country. In the same context, the Colombian Corporation of Agricultural Research (Agrosavia) took the initiative to formulate the agroclimatic adaptation and prevention models project (MAPA), with the purpose of contributing to the development of local capacities of the agricultural technical assistance subsystem (Ssata) for the dissemination of a culture of adaptation to climate change and climate variability.

This is based on the premise that networks are spaces where knowledge is exchanged, generated and shared as an engine of development and competitiveness (Pérez and Castañeda, 2009). Additionally, networking can help facilitate access to resources, access to new ideas and accelerate knowledge transfer (Powell and Grodal, 2006).

Network analysis is a tool that has been used in different fields, such as economy, marketing, health and of course in the agricultural sector, in the latter it has been used to understand the processes of adoption and dissemination of technologies among producers and manage innovation (Monge and Hartwich, 2008; Aguilar-Gallegos *et al.*, 2016). Regarding the agroclimatic risk issue, networks could have great potential, since they offer two valuable resources: flows of knowledge and large-scale action. Nevertheless, the challenge is to identify the right strategy to make the best use of networks and measure the tangible impact of management (Schwaab and Seibold, 2014).

In the MAPA project, social network analysis (SNA) was used in order to optimize the circulation of information on the subject of agroclimatic risk (technical message) among the agricultural technical assistants that make up the agricultural technical assistance subsystems of 18 departments in Colombia. In this sense, the objective of this research was to analyze the changes in the networks of technical trust of agricultural technical assistants (ATA), after a process of management and dissemination of a culture of agroclimatic risk over a period of two years in the departments of Cundinamarca, La Guajira and Valle del Cauca, Colombia.

## Materials and methods

The agroclimatic adaptation and prevention models (MAPA) project was developed in 54 municipalities of 18 departments of Colombia: Atlántico, Bolívar, Boyacá, Cauca, Cesar, Chocó, Córdoba, Cundinamarca, Huila, La Guajira, Magdalena, Nariño, Norte de Santander, Santander, Sucre, Tolima and Valle del Cauca. In which 54 livestock and agricultural production systems were considered as priorities: topito chili, dual-purpose livestock, banana, cacao, sugarcane, lulo, white maize, industrial cassava, rainfed rice, among others.

In this study, three representative departments of Colombia were taken as a sample of the MAPA project management process: Cundinamarca, La Guajira and Valle del Cauca (Figure 1), of which systematized information was available at the beginning of the project in 2015 and at its end in 2017.



**Figure 1 Geographic location of Cundinamarca, La Guajira and Valle del Cauca in Colombia.**

For the study, two surveys were designed and applied, the first of which was used to characterize the departmental agricultural technical assistance subsystem (SSATA) and analyze the perception of agricultural technical assistants (ATA) regarding agroclimatic risk. The survey was organized into three blocks: 1) general information of the technical assistant, such as their age, experience, level of education, among others; 2) networks of technical trust and information on the provision of the technical assistance service, where they were asked to organize in order of importance the tools they consider necessary to provide the technical assistance service; and 3) knowledge about agroclimatic risk, perception and climate variability.

Once the different actors providing the technical assistance service in each territory had been identified, the second survey was carried out to analyze the technical trust links of the ATAs and to create the sociogram of the network, the basic question was: which of your colleagues do you consult when you have a technical doubt? This allowed to inquire about those people to whom they turn to consult technical aspects of the production system or other doubts related to their performance as a technical assistant. With the information obtained, the graph of the network of technical trust was constructed, in which the existing relationships between the ATAs, already identified in the characterization, were evidenced.

The characterization and perception survey, as well as the relationship survey, was applied to the ATAs of each department in two moments of observation, at the beginning of project January 2015 and at the end, in January 2017. In the case of the departments analyzed in this research, at the beginning of the project the characterization and perception survey were answered by 217 technical assistants, who were identified in the field using the snowball technique. In 2017 a survey similar to that of 2015 was conducted but through a virtual platform, responses were obtained from ten agricultural technical assistants from Cundinamarca, seven from La Guajira and eleven from Valle del Cauca. The number of relationship surveys is detailed in Table 1.

**Table 1. Number of ATAs that responded to the relationship survey by department analyzed.**

Department	Number of actors (January 2015)	Number of actors (May 2017)
Cundinamarca	58	30
The Guajira	41	29
Valle del Cauca	41	53

Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

With the information obtained from the surveys, an Excel database and a notepad file with the links between the agricultural technical assistants were constructed. Each one was assigned an identifier and a consecutive number for easy handling of the data in the sociograms of the networks. For the elaboration of the graphs and calculation of the indicators of the networks, the software Ucinet version 6.628 for Windows was used.

The indicators of the network calculated were: density, which refers to the percentage of existing relationships between the possible ones, and the centralization index, which indicates how concentrated the links are by an actor or group of actors. The indicators of ego or node used were: size of the nodal network, which refers to the number of actors with whom it is directly connected; and intermediation that shows the number of pairs not directly connected in the actor's network, divided by the total number of existing pairs.

The calculation of the coverage of diffusion and structuring of each actor was carried out with the program Keplayer2<sup>®</sup>. Harvest, diffuse and disrupt algorithms were used to identify the main ATAs that could have access to information (collecting actors), influence others through their links (source actors) or cause the fragmentation of the network (articulating actors), according to the nodal degree and their proximity in the network (Borgatti, 2006).

To measure changes in the ego or node indicators of the technical trust networks of the agricultural technical assistants at the beginning and at the end of the project, a 't' test was used in independent samples. This test permit to observe whether the difference in the means of the indicators is statistically significant. Statistical analysis of the data was performed in the Statistical Analysis Software (SAS) v.9 package. These indicators and the graphical analysis of the networks were useful to measure the changes generated by the effect of the intervention of the models of adaptation and agroclimatic prevention (MAPA) project.

## Results and discussion

### Characterization of agricultural technical assistants

In the department of Cundinamarca, the predominant institutional figure for the provision of the technical assistance service are the municipal agricultural technical assistance units (UMATA), the Secretariats of Economic Development (SDE) and the Municipal Secretariats of Agriculture (SAM). In Cundinamarca, 105 out of 116 municipalities operate under this modality, the type of recruitment of technical assistants is annual and sometimes for a period of four years, which corresponds to the election period of the municipal mayors.

On the other hand, when technical assistance is provided by entities providing the agricultural technical assistance service (EPSAGRO), the employment relationship is carried out through fixed-term contracts with a duration of no more than ten months. This type of hiring for short periods directly affects the continuity of personnel in the work areas, there is high turnover and mobility of the ATAs, the permanence of the actors in the territories and even of the entities is not guaranteed and generates labor instability (Méndez, 2015). This affects the continuity of intervention processes and capacity building processes (Corpoica, 2015a; Monsalvo *et al.*, 2017).

In contrast, in Valle del Cauca, there are different entities that provide the technical assistance service, such is the case of the Provincial Center of Agribusiness Management of the Southwest that is made up of the municipalities of: Palmira, Candelaria, Florida, Guacarí, Ginebra, Pradera and El Cerrito, which work closely with the secretariats of agriculture of these municipalities (Corpoica, 2015b). The institutional development in this department is significant, the presence of productive guilds in the department is relevant, such is the case of the Horticultural Association of Colombia (Asohofrucol), the National Federation of Coffee Growers and the Association of Sugarcane Growers of Colombia (ASOCAÑA) that provide the technical assistance service to their associates.

In the three departments analyzed in this paper, the technical assistance service is mostly offered by men around 40 years of age, and with an average experience in the activity of less than 10 years (Table 2). In relation to the academic background of the ATAs, 39.0% have professional training in agricultural areas such as agronomic engineering, veterinary medicine and animal science. Similar to what has been reported in other studies where it has been found that extension services are provided mainly by men and with training in agronomic and animal sciences, leaving aside the social sciences (Landini, 2013; Mayoral-García *et al.*, 2015; Monsalvo *et al.*, 2017).

In Cundinamarca 61% of the ATAs presented an educational level of technician and technologist, according to Law 30 of 1992, by which the public service of Higher Education is organized in Colombia, technical education is the one that offers training programs in occupations of an operational and instrumental nature and of specialization in their respective field of action, without prejudice to the humanistic aspects of this level and technological education offers training programs in occupations, academic training programs in professions or disciplines and specialization programs, on the contrary, in Valle del Cauca a greater number of specialists was observed.

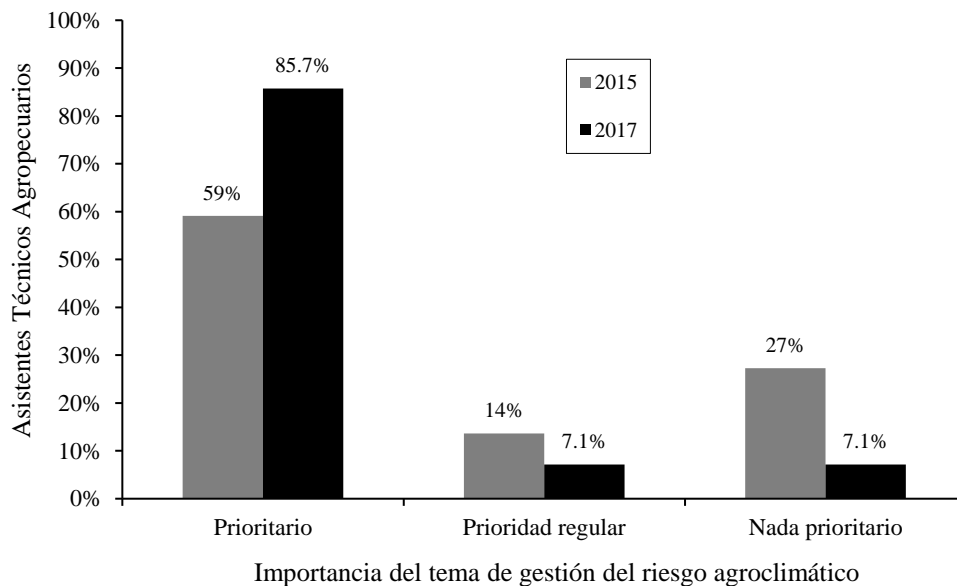
**Table 2. Characteristics of the technical assistants in the departments analyzed.**

Variable		Cundinamarca	La Guajira	Valle del Cauca
Age (years)		36	43	42
Men%		75.5	88.8	71.1
Women%		24.5	11.2	28.9
Experience as an ATA (%)	1-5 years	42.5	38.1	44.2
	6-10 years	20.3	26.3	7.7
	11-16 years	9.3	13.6	13.5
	>16 years	27.7	19	34.6
Level of education (%)	Technician	42.5	31.8	17.3
	Technologist	18.5	13.6	19.2
	Professional	31.4	41.8	42.3
	Specialist	9.3	11.8	21.2

Surveys applied to the ATAs of the MAPA project, 2015.

### Perception of agricultural technical assistants about agroclimatic risk management

At the beginning of the process of disseminating information within the framework of the agroclimatic adaptation and prevention models (MAPA) project, it was observed that the ATAs of Cundinamarca, La Guajira and Valle del Cauca perceived agroclimatic risk management as a tool or issue of little relevance to provide an adequate technical assistance service, about a third (27%) considered it a little or no priority issue (Figure 2). This could be explained because the ATAs of Colombia, like those of other countries, give greater relevance or focus on mainly technical issues, however, the social, economic and environmental aspect is also the task of the country's rural development agents (Sáenz-Torres, 2014).



**Figure 2 Importance given by the ATAs to the issue of agroclimatic risk management.** Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

The MAPA project structured a training strategy called formative moments that was developed as follows: 1) analysis of climate change concepts; 2) management of agroclimatic information (climate data, climatic variables and how they are interpreted); 3) expert system and early warning systems (such as making decisions based on information); 4) management of agroclimatic risk (assessment of agroclimatic risk in production systems); and 5) technological options of the defined crops (assessing technologies to be implemented in the production systems and to reduce agroclimatic risk).

For its diffusion, WhatsApp groups were formed where a weekly communication routine was generated, and key actors were identified to disseminate specific topics. Practical and participatory face-to-face workshops every four months with technical assistants. Once the training strategy of the MAPA project was completed in 2017, climate information was recognized by 85.7% of the ATAs as a priority or necessary tool in technical assistance, it is worth mentioning that their assistance was by their own decision and financed with their own resources.

### Networks of technical trust of agricultural technical assistants

In the departments of Cundinamarca and La Guajira, networks were established in 2015 with 58 and 41 actors respectively, and these networks at the end of the process were of 30 and 29 actors (Table 3). In this regard, Zarazúa-Escobar *et al.* (2012) provide empirical evidence on the evolutionary process and integration into networks, where those that involve collaboration tend to decrease in relation to those that are only integrated by a level of recognition among the actors.

**Table 3. Indicators of the technical trust networks of the ATA, 2015 and 2017.**

Indicator	Cundinamarca		La Guajira		Valle del Cauca	
	2015	2017	2015	2017	2015	2017
Network size	58	30	41	29	41	53
Number of links	630	148	617	94	117	304
Input centralization (%)	23.4	25.3	35.7	25	15.8	63.2
Output centralization (%)	27.0	28.8	38.3	28.7	8.1	20.1
Density (%)	19.1	17	37.6	11.6	7.1	11

Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

In the two networks the centralization index of output was slightly higher than that of input, which showed the existence of a group of agricultural technical advisers who collect information and anxious to acquire new knowledge through their links, obtaining information from about one third or more of the members that make up the networks.

On the other hand, the Valle de Cauca network showed a different trend, the number of nodes in the network increased and their links were close to tripling, which was reflected in an increase in the density of relationships 3.9%. Sometimes the size of the networks increases, due to the relationships of an actor sent to the network, they provide access to several and diverse nodes, allowing them to reach them and insert themselves into the network (Aguilar-Gallegos *et al.*, 2016).

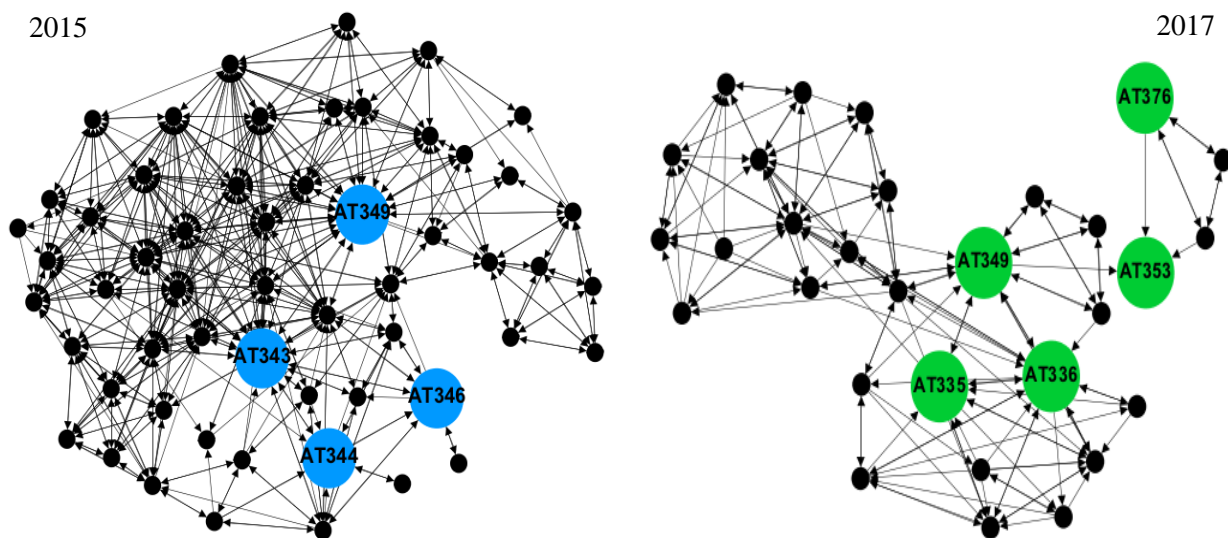
Increases in density are related to higher levels of homogeneity in the behavior of individuals (Monge and Hartwich, 2008), so in this case the density was reflected in greater exchange of information and therefore, learning. Likewise, the centralization index of input increased in the network by 63.2%, due to the existence of actors with a central position and recognized by their peers as sources of information. Input centralization levels increase positively when there is a small number of actors recognized as sources of information (Aguilar-Gallegos *et al.*, 2017).

In this case, they provided information on the issue of agroclimatic risk to more than half of the actors in the network in 2017. Social network analysis (SNA) is useful for analyzing the patterns of interaction between farmers (or technicians) and actors present in a network, which permits to understand the processes of searching for information and knowledge (Aguilar-Gallegos *et al.*, 2016). The tool in the present study made it possible to identify the ATAs with a strategic position in the network, which given their good technical reputation would guarantee the circulation of the technical message on agroclimatic risk and with greater coverage among the members of the networks.

The coverage of these actors is relevant in the sense that their scope is not limited only to direct links, but, if they remain in the territory, they could have a greater scope in the teaching process with other technicians of the network or the region (López *et al.*, 2016).

### Cundinamarca

The Cundinamarca network in 2015 was observed structured and with high connectivity, two actors identified with the codes AT343 and AT349 were the main sources of information, and in turn, collectors of information in the network with a coverage reached of 96.4% in their two roles, so they were ideal to transmit the technical message on agroclimatic risk (Figure 3).



**Figure 3** Network of technical trust of the ATAs of Cundinamarca 2015 and 2017. Surveys applied to the ATAs of the MAPA project, 2015 and 2017.



The first was part of the entities providing the agricultural technical assistance service (EPSAGRO)-Horticultural Association of Colombia (ASOHOFrucol) in the municipality of Útica, and the second, of the municipal unit of agricultural technical assistance (UMATA) of the municipality of Ubaté.

On the other hand, due to the dense structure of the network, it did not depend on articulating actors or links that could cause a rupture in the network due to its exit, the AT344, an independent technician from Caparrapí and the AT346 of UMATA of the municipality of Quebradanegra showed the highest fragmentation index with only 13%. However, networks are not static and tend to show temporal dynamics depending on the stage of the management process (Bodin *et al.*, 2017) and the final network showed a lower degree of connectivity than its counterpart in 2015.

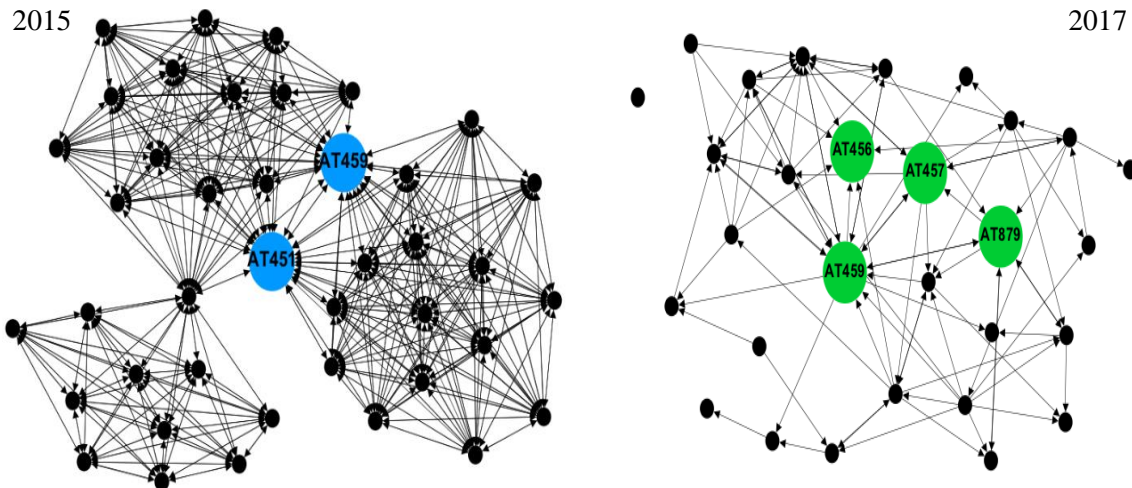
For 2017, the Cundinamarca network was observed to be smaller and divided into four subnets, joined by certain actors. The main associated cause was the rotation of members in the network and the entry of agricultural technical assistants from the committee of coffee growers who provided assistance in different distant municipalities. In this sense, five key actors, two actors as sources of information with the keys AT336 and AT353 were identified, which belonged to different areas: the first, from the Secretariat of Economic Development of the municipality of Anapoima, and the second, from the Secretariat of Departmental Agriculture.

Due to the articulated structure of the network, with this combination of actors a 100% coverage was achieved in the network for the dissemination of information on agroclimatic risk, that is, that these actors by their position could send the information to the entire network. Regarding the information collectors identified were the AT335 and AT376, with the highest coverage in the network with 96.4%. In Cundinamarca, it was observed that the AT336 not only had the function of information provider but also as an articulator or intermediary in the network, serving as a link between the three subnets of the provinces of Tequendama, Gualivá and Valle de Ubaté. The AT336 together with the AT349 reached 28.4% of link fragmentation due to its role as a local-regional or national node.

## **La Guajira**

The network of La Guajira in 2015 was divided into three subnets, connected by two important actors AT451 and AT459 of the Asohofrucol organization and with action in the municipalities of Dibulla, Maicao, Riohacha and South of La Guajira, who reached 100% coverage as sources and seekers of information in the network (Figure 4). In addition, its fragmentation index was 53.7%, which denoted the importance of encouraging their participation in the strategy.

The first from the Secretariat of Productive Development, and the second from Asohofrucol, these actors reached 70% coverage in the network for the dissemination of information on agroclimatic risk. In the same sense, the AT457 and AT459 were identified as the information-seeker actors with the maximum coverage of the network, with a percentage of 88.8%. The AT457 along with AT879 had the highest fragmentation index in the network, with 32.1%. These actors are part of two recognized organizations: Colombian Agricultural Institute (ICA) and Cerrejón Foundation, both located in the municipality of Uribia, so their role of coordinating or linking to other actors in the network is understood.

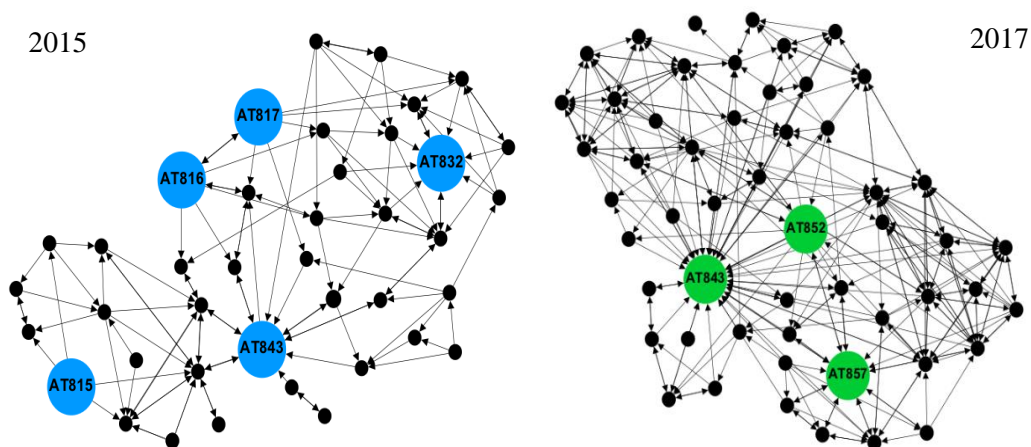


**Figure 4** Network of technical trust of the ATAs of La Guajira 2015 and 2017. Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

### Valle del Cauca

The Valle del Cauca network in 2015, five actors with a central position were identified, the actors with the keys AT832 and AT843 were the main sources of information with 89.7% coverage in the network, the first is part of the Institute of Professional Technical Education (Intep) of the municipality Roldanillo, and the second of the Colombian Corporation of Agricultural Research (Figure 5). The AT815 and AT817 were the information collector actors with the highest coverage with a percentage of 61.5%, since their area of action was different (Andalucía and Cali-Ginebra-Guacari) and belonged to different organizations (Secretariat of Development of Andalusia and the Asofrunidos Community Association of Ginebra).

Due to the structure of the Valle del Cauca network, the two main articulating actors AT816 and AT843 obtained a fragmentation index of 43.7%, that is, if these actors were excluded from the strategy, the network could have a strong rupture between its links.



**Figure 5** Network of technical trust of the ATAs of Valle del Cauca 2015 and 2017. Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

In 2017 the Valle del Cauca network reached a greater integration, the articulating actors AT843 and AT857 only reached a coverage of 21.3%, which evidenced a lower fragility of the network. In 2017, the actor AT843 part of the MAPA project managed to position itself in the network and stood out as the main source of information with a coverage of 98.1%, as well as collector of information along with the AT852 with a coverage 92.2%. This situation favored greater connectivity and more direct communication with the technical assistants of the department.

In the Valle del Cauca network, the degree of intermediation of the actors decreased significantly ( $p < 0.05$ ) (Table 4). On the contrary, the intermediation indicator in the Cundinamarca and La Guajira network increased significantly ( $p < 0.05$ ), which shows that a greater number of bridges or links were built in the networks to promote the diffusion of information.

**Table 4. Comparison of means of ego or node indicators in the 2015 and 2017 networks.**

Indicator	Department	Mean 2015	Mean 2017	Difference	Significance
Nodal network size	Cundinamarca	11.6	6.6	-5	0
	La Guajira	15.1	5.4	-9.7	0
	Valle del Cauca	4.6	8	3.4	0
Intermediation (%)	Cundinamarca	0.3	0.4	0.1	0
	La Guajira	0	0.7	0.7	0
	Valle del Cauca	0.7	0.6	-0.1	0

Surveys applied to the ATAs of the MAPA project, 2015 and 2017.

In this way, it could be affirmed that, in the processes of dissemination of knowledge, it is vital the presence of catalysts or orchestrators for the management of networks and promoting the entire system, generating flows of knowledge, and an effective dissemination of knowledge (Muñoz and Santoyo, 2010). To achieve collaboration among members in this type of networks, it is necessary to trust, involve skills and competencies of the participants and share norms, beliefs and values (Luna and Velasco, 2005).

## Conclusions

The social networks analysis (SNA) permitted to know the particularities of each of the departmental networks serving as input to carry out a differentiated knowledge management of the agroclimatic risk, according to the territory and actors involved in the agricultural production systems. In this sense, the analysis of the networks of technical trust of the agricultural technical assistants in two moments of observation (at the beginning and end of the project) permitted to assess the changes that occurred as a result of the intervention strategy of the MAPA project for the strengthening of the agroclimatic culture and to improve the diffusion of information.

In an unstable work environment and where the role of technical assistance is provided by different actors, knowledge management in networks of technical trust permitted to generate a training process that resulted in a change in the perception of technical assistants about the importance of

the agroclimatic risk issue, as a cross theme to technical assistance. Also, improve the positioning of local actors as coordinators or animators of their own network to ensure the sustainability of the project and deepen its impact in each of the departments.

The management of information through networks of technical trust among agricultural technical assistants was effective and efficient in the use of resources, due to the identification of actors with greater power to disseminate information and targeting to optimize the relations of exchange of information on the subject of agroclimatic risk.

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