

**Social Network Analysis of
Agroecological Knowledge
Construction in Areas of Settled
Farmers in Sergipe, Brazil**



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Marcos Aurélio Santos da Silva

Edmar Ramos de Siqueira

Fernanda Amorim Souza

Pedro Zucon Ramos de Siqueira

Marília Andrade Fontes

Jorge Enrique Montalván Rabanal

Joézio Luiz dos Anjos

Karoline Coelho Ferreira

Cristiane Otto de Sá

Embrapa Tabuleiros Costeiros
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Embrapa Tabuleiros Costeiros

Av. Beira Mar, 3250

49025-040 Aracaju, SE

Fone: (79) 4009-1344

Fax: (79) 4009-1399

www.embrapa.br/tabuleiros-costeiros

www.embrapa.com.br/fale-conosco

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Marcos Aurélio Santos da Silva¹

Edmar Ramos de Siqueira²

Fernanda Amorim Souza³

Pedro Zucon Ramos Siqueira⁴

Marília Andrade Fontes⁵

Jorge Enrique Montalván Rabanal⁶

Joézio Luiz dos Anjos⁷

Karoline Coelho Ferreira⁸

Cristiane Otto de Sá⁹

Abstract

The rural social network of settled small farmers for knowledge construction in the Southern Rural Territory of Sergipe has been formally created since 2012 by a project of research carried out by the Embrapa, but it was never evaluated by formal methods. This research mapped the rural social network and evaluated it by means of the relations among social actors (settled small farmers and facilitators) using centrality measures (degree and betweenness). Results show that the mapped rural social network for knowledge construction in

¹Computer Scientist, master in Applied Computing, researcher at Embrapa Coastal Tablelands, Aracaju, SE

²Forestry Engineer, doctor in Forestry Sciences, researcher at Embrapa Coastal Tablelands, Aracaju, SE

³Degree in History, master in Development and Environment, analyst at Embrapa Coastal Tablelands, Aracaju, SE

⁴Bachelor of Tourism, master in Development and Environment, technician at Center for Agricultural Training Dom José Brandão de Castro (CEFAC), Aracaju, SE

⁵Forestry Engineer, master in Agroecosystems, São Cristóvão, SE

⁶Engenheiro-agrônomo, master in Geography, technician at Center for Agricultural Training Dom José Brandão de Castro (CEFAC), Aracaju, SE

⁷Agronomist Engineer, doutor in Agronomy, researcher at Embrapa Coastal Tablelands, Aracaju, SE

⁸Sociologist, technician at Center for Agricultural Training Dom José Brandão de Castro (CEFAC), Aracaju, SE

⁹Veterinary, PhD. in Zootechnology, researcher at Embrapa Coastal Tablelands, Aracaju, SE

the Territory has a very low index of centrality, is composed of four components, presents homogeneity among the settled small farmers, is heterogeneous in terms of types of social actors, has a limited number of connections between settled small farmers from different settlements, has an almost star structure with one facilitator with the highest in-degree index and with one small farmer with the highest betweenness index.

Index terms: centrality measures, sociometric, agroecology.

Análise de Redes Sociais de Construção de conhecimento Agroecológico em Áreas de Assentamentos Rurais em Sergipe, Brasil

Resumo

A rede social rural, de pequenos agricultores assentados, para a construção do conhecimento no Território Sul de Sergipe vem sendo criada desde 2012 por dois projetos de pesquisa liderados pela Embrapa, mas nunca foi mapeada e avaliada por métodos formais. Esta pesquisa mapeou essa rede social e a avaliou por meio das relações entre os atores sociais (pequenos agricultores assentados e facilitadores) usando medidas de centralidade (grau e intermediação). Os resultados mostram que a rede social rural mapeada para a construção do conhecimento no Território tem um índice muito baixo de centralidade, é composta por quatro componentes, apresenta homogeneidade entre os pequenos agricultores sedentários, é heterogênea em termos de tipos de atores sociais, tem um número limitado de conexões entre pequenos agricultores de diferentes assentamentos, tem uma estrutura quase estrelada com um facilitador com o maior índice em graus e com um pequeno agricultor com o maior índice de intermediação.

Palavras-chave: agroecologia, medidas de centralidade, sociometria.

Introduction

The Brazilian rural space is a complex and diverse environment composed of a multitude of institutions, social movements, governmental organizations, small, medium and big farmers and so on (SCHNEIDER et al., 2006). This plurality makes the decisions about public policies for agroecological knowledge production more challenging, mainly when the settled small farmers are the target public.

The agroecological knowledge production in these rural properties demands strategies adapted to each reality, taking into account that the traditional methods for technology transfers does not match, always, actual farmers' requirements (MATTOS et al., 2006). In fact, the social process on the ground are of a complex nature, due to the increasing of interdependencies among social actors. Then, an approach to leverage the efficiency in small rural properties should consider the capacity for self-organization and endogenous knowledge construction.

To approach it, the Brazilian Agricultural Research Corporation (Embrapa) has been conducting a series of research projects, from 2008 to date, in rural settlements of the Southern Rural Territory of Sergipe, Brazil. These projects intended to boost the adoption of agroecological practices by knowledge exchanges in small rural communities from agrarian reform using the 'campesino a campesino' strategy (HOLTZ-GIMÉNEZ, 2008; SOSA et al., 2010). This proposed action aims to improve the communication among settled small farmers by promoting meetings, at a regular base and intermediated by facilitators from organizations, to exchange ideas, to discuss about agroecological practices and to design new plans for the construction of new knowledge from this interactive experience and by means the establishment of a formal social network with these settled small farmers establishing a formal rural social network. In fact, if you interpret any rural social collectivity as a mathematical graph and analyze it as a network your research object will be a rural social network.

The formal analysis of rural social networks is a relatively recent field of research and still needs more empirical work (BODIN and CRONA, 2009; ISAAC, 2012; MANSON et al., 2016). According to Bodin and Crona (2009) there are key questions which, if answered, could help explain a rural social network, such as: How settled small farmers construct their knowledge and how the network contributes to that? How the rural social cohesion affects the group engagement or the appearance of novelties? How the subgroups influence the knowledge construction? How the rural social network self-organize and evolve? How trust constraint the network design over time? But, there is no simple answer to these questions.

In fact, only a systemic approach based on logical and empirical ground work could help to model the connected real world, mainly in rural areas where there are rare material about human behavior, preferences and connections. This systemic approach can be conducted and measured quantitatively by the Social Network Analysis (SNA) framework which comprises a set of computational and statistical methods.

Bodin and Crona (2009) differentiates the way the social networks arrange themselves to knowledge construction and to collective action. Analyzing a natural resource management, these authors found out that knowledge development requires less ties than collective action, because the former depends more on the source of new information. In fact, Ramirez (2013) stated that in a traditional technological diffusion process of a precision leveling irrigation system the innovators, which are connected to the external source of information, influences more the degree of adoption than the imitators, which are strongly connected to each other but have less access to the external source.

Although these external links to new information sources are crucial, the social network evolving is not a linear and homogeneous phenomena (RAMIREZ, 2013). In a real situation, there is a trade-off between the social cohesion, how strong people are connected to each other, and the capacity to construct new knowledge with weak ties (ISAAC, 2012; POUDEL et al., 2015). In a process of diffusion

of an integrated Agroforestry approach, Isaac (2012) showed that, if there exists an organization (external source of new information) near to the producer, they will prefer to connect with them instead of to a fellow producer. Hence, a high similarity between the farmers can be a handicap to the exchange of agricultural information and, thus, to the behavior change and knowledge production. A similar conclusion can be extracted from (BODIN and CRONA, 2009; POUDEL et al., 2015).

One conclusion of these works is that it is good to have a heterogeneous social network, because it will guarantee the needed arrangement to tackle intensive collaborative problems (e.g., collective decision making) or new and complex problems (e.g., knowledge construction about a new agricultural practice). Following a knowledge transfer by a demonstration unit during three years, Wood et al. (2014) concluded for the importance of heterogeneous social networks to solve complex problems, for instance, agroecological knowledge production.

Bodin and Crona (2009) and Wood et al. (2014) showed that the similarity between rural producers increases the trust between them, which work in favor of the self organization of the social network. In fact, the combination of trust and reciprocity, information and knowledge boosts the self-organization of the social network toward technology adoption or adaptation (JANA et al., 2013; RAMIREZ, 2013; WOOD et al., 2014).

The aim of this work had been the use of formal methods to map and explore the created rural social network for knowledge construction in the Southern Rural Territory of Sergipe using Social Network Analysis methods, designing the sociogram of this social network and identifying key social actors using centrality measures. Additionally, it had been investigating how the facilitators contribute to the rural social network design, which are the most relevant social actors (settled small farmers) to the spread of knowledge, and how fragmented is this social network.

Material and Methods

The research has been performed in thirteen rural settlements located at seven municipalities (Araúá, Cristinápolis, Umbaúba, Tomar do Geru, Santa Luzia do Itanhy, Estância e Itaporanga D’Ajuda) of the Southern Rural Territory of Sergipe, between August and December 2015 (Figure 1). These communities have participated in the Embrapa’s research projects to create a rural social network for knowledge construction about agroecological practices. It had interviewed 40 settled small farmers.

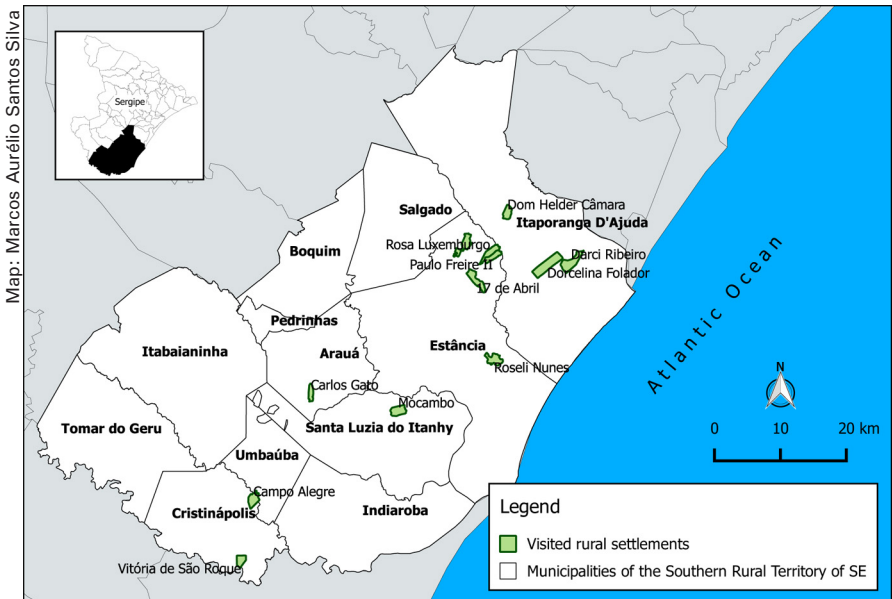


Figure 1. Geo-localization of the thirteen visited rural settlements in the Southern Rural Territory of Sergipe.

In 2015, the research team applied questionnaires to each settled small farmer asking open questions about the level of dependence (food, energy, water and meragricultural suppliers), living conditions, main activities, general level of technification, general agricultural activities in their rural property, and about what they taught, learnt and adopted

during the period of the execution of the project, between 2012 and 2015. To construct the rural social network it had been asked these three questions: 1) Who is the first person, from your community, which comes to your mind when you think about the exchange of agroecological knowledge? 2) Who is the second person, from your community, which comes to your mind when you think about the exchange of agroecological knowledge? Who is the first person, outside your community, which comes to your mind when you think about the exchange of agroecological knowledge? Each relation between the respondent and the indicated person had been qualified by type (relative, friend, other) and by frequency of contact (diary, weekly, monthly, annually).

The mapped rural social network, modeled as a directed graph, had been explored by sociograms and Freeman measures of centrality (degree and betweenness), using the UCINET/Netdraw softwares (WASSERMAN; FAUST, 1994; BORGATTI et al. 2002; HANNEMAN; RIDDLE 2005). In fact, there is no a priori hypothesis about the studied rural social network, so we didn't consider the use of more sophisticated measures at this exploratory stage of the research. Besides, the centrality is a key factor in the propagation and production of agroecological knowledge as shown by the literature.

Results and Discussion

The agroecological knowledge and the settled small farmers

The main agroecological knowledge, perceived by agroecological practices, exchanged among settled small farmers by the intermediation of some facilitators from assistenship and research institutions are: biogeo, composting, organic fertilizer, consortium, biopesticide, wormery, the adoption of other varieties, collective orchard, rotation of crops, AgroForestrys Systems (AFS's), irrigation, exchange of seeds and hen house construction and maintenance. The Figure 2 shows the frequency of each one taught, learnt and adopted by the settled small farmers in the Southern Rural Territory of Sergipe. From this graph it

had been concluded that organic fertilizer was the most learnt, the wormery the most adopted and composting the most taught among these settled small farmers, which, also, showed that for some practices (e.g., biopesticide, the adoption of other varieties) they cited more adoptions than learnt. This can be explained by the fact that the small farmer can adopt one practice which was not learnt during the period of the project.

Despite the differences among these 40 settled small farmers, they share some characteristics, such as: difficulties to access financial loans, insignificant livestock production, commercialization of their rural products on local fairs, low level of technification and a high level of dependence on food, energy, water and agricultural input suppliers. The Figure 3 shows four examples of agricultural practices which can be applied, exchanged and improved to reduce some of these dependencies.

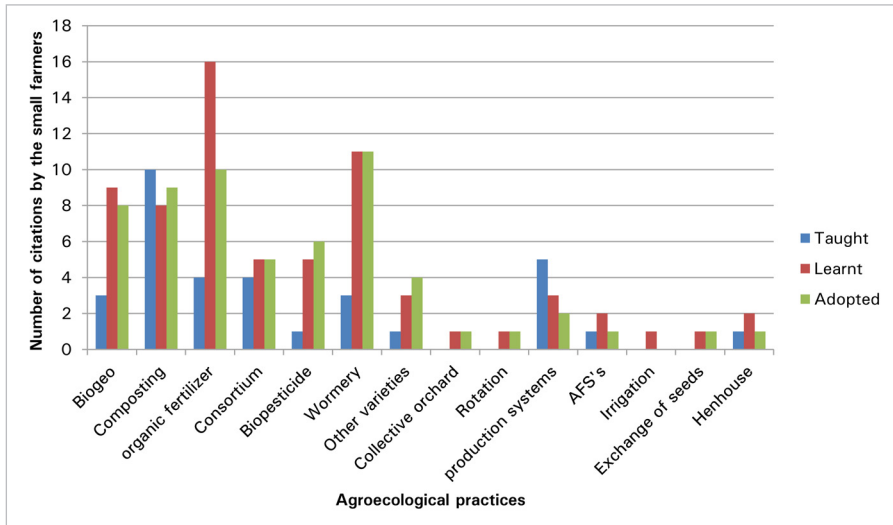


Figure 2. Distribution of the exchanged knowledge about agroecological practices among the settled small farmers from the Southern Rural territory of Sergipe.



Figure 3. Agroecological practices exchanged during the meetings among settled small farmers and the facilitators of organizations: a) biogeo; b) wormery; c) composting; and d) Agroforestry systems.

The sociogram

The sociogram of the rural social network created from the three questions about with whom the settled small farmer exchange ideas about agroecological knowledge shows that this network is composed of four components (Figure 4). The big one which gathers the majority of settled small farmers and facilitators, another one with eight settled small farmers and one facilitator, and more two to three and only one small farmer. The network centralization index is 0,73%, very low, but it reflects the limited number of maximum connections established by the research. From the sociogram and considering the spatial localization of each point it is also possible to infer that the distance of the node from the capital of Sergipe, Aracaju, may influence the connectivity among the social actors which are located far from this city.

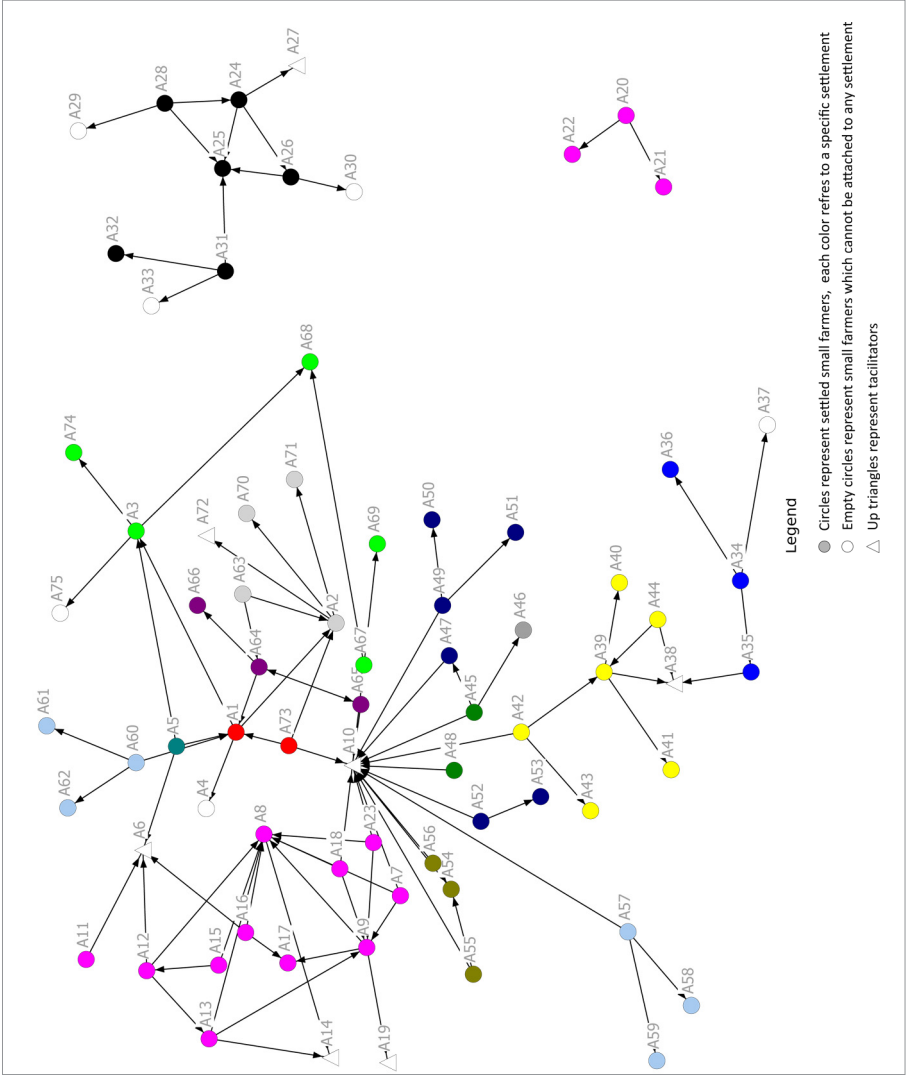


Figure 4. Sociogram of the rural social network for knowledge exchange in the Southern Rural Territory of Sergipe.

The most popular relation type among settled small farmers is by friendship, and between settled small farmers and other persons outside the settlement is the facilitator from organizations. The frequency of contact and communication is more intense, as expected, between settled small farmers from the same settlement. In general, they communicate on a weekly base. In the other hand, the interaction between settled small farmers and the facilitators occur monthly.

The high degree of socioeconomic profile similarity among settled small farmers suggests a high level of trust, as appointed by Isaac (2012). In fact, despite the impossibility of the mapped social network to show up the level of trust among social actors, it can be inferred from the personal statements during the interviews and by the degree of the engagement in collective decision making about the Southern Rural Territory of Sergipe in forums and meetings.

The sociogram shows that each settlement connects with each other by means of the external sources of information (the facilitators). Although the questionnaire limited number of connections per person, it can be inferred from the rural network that there is little connection between each settlement and outsiders. This can be concluded observing the fact that almost any settled small farmer cited another one as an outsourcing provider. So, the facilitators add heterogeneity that is fundamental for the knowledge construction as stated by Bodin and Crona (2009) and Ramirez (2013).

The centrality measures

The Table 1 shows the in-degree statistics for the most demanded social actors (small farmer or facilitator). This table also shows, in the last column, the number of rural settlements connected to each social actor. In fact, there is a concentration of agroecological demands in only one social actor, A10. The next one represents more a leadership of the social actor A8 in this own rural settlement.

From the sociogram and from this centrality measure we concluded that the social actor A10 plays an important role in the entire network and that his absence could generate a very fragmented social network.

In fact, at the beginning of the project the researchers assumed that only settled small farmers could be considered as part of the network and facilitators would play a secondary role in the knowledge construction. However, this study showed the opposite. The settled small farmers need the facilitators as trusted references do support the use of agroecological practices. As the only agronomist among the facilitators also helps to explain this rate of in-degree measure of the social actor A10.

The majority of the rural settlements associated with the social actor A10 is located in a small set of municipalities. In fact, in these regions we experienced a high social cohesion among settled small farmers engaged in this network and, consequently, they are more likely to maintain the connections among them.

Table 1. List of six social actors with the highest in degree.

Social Actor	Type	In degree	Number of rural settlements
A10	Facilitator	16	9
A8	Settled farmer	8	1
A1	Settled farmer	4	4
A6	Facilitator	4	2
A25	Settled farmer	4	1
A9	Settled farmer	4	1

The Table 2 shows the betweenness statistics for some social actors. It is worth to notice, that the social actor (small farmer) A1 appears as the most central and as a reference for the other. Only few social actors demonstrated a relevant betweenness. The social actor A1 plays a key role as a trusted political reference among the settled small farmers. In fact, trust is so important as well as the technical knowledge in this rural social network formation and evolution. In general, the settled small farmer interprets these two information (trust and knowledge) before establishes a strong connection with other farmer or facilitator.

Table 2. List of seven social actors with the highest betweenness.

Social Actor	Type	Betweenness	% of total Betweenness
A1	Settled farmer	42,0	75,7
A3	Settled farmer	21,0	37,8
A2	Settled farmer	21,0	37,8
A64	Settled farmer	20,0	36,0
A9	Settled farmer	12,0	21,6
A8	Settled farmer	6,5	11,7
A13	Settled farmer	6,5	11,7

From the sociogram, the centrality statistics (in-degree and betweenness) and from the empirical research results it is possible to draw some conclusions about the questions of research proposed by Bodin and Crona (2009) concerning this case study:

How settled small farmers construct their knowledge and how the network contributes to that?

Settled small farmers have little access to formal instruction; have limited support from the governmental agency for technical assistance and they are facing strong challenges to overcome natural limitations do develop their agricultural activities. Hence, the main source of knowledge construction is the relations of direct reciprocity with each other based, mainly, on trust gained by a constant communication with their neighbor’s fellows. This, as stated by Issac (2012) and Poudel at al. (2015), can be a limitation if there is not an alternative external source of new information.

How the rural social cohesion affects the group engagement or the appearance of novelties?

As perceived in the literature (ISAAC, 2012; RAMIREZ, 2013; POUDEL et al., 2015), groups with a strong cohesion presents some difficulties to produce new knowledge because there is little new information to allow that. Therefore, in our rural social network, the facilitators showed to be very important as sources of new information and as

animators of the meetings between the settled small farmers. On the other hand, groups with strong ties tend to use more properly the new information provided by the facilitator, so they are more likely to produce new knowledge because the high level of communication and exchange of ideas. Nonetheless, it is worth to note that, as observed by Brodin and Crona (2009) high similar groups alone can be a handicap to exchange of information.

How the subgroups influence the knowledge construction?

In our rural social network the geographical space is determinant in the group formation. In general, there is a spatial dependence of group formation, so neighbors tend to flock together and the strength of this connection is strongly related to the presence or absence of a facilitator to start the exchange of new experiences among them. This spatial dependence and, consequently, some heterogeneity which came from different geographical realities could generate heterogeneous social networks more likely to produce new knowledge (WOOD et al., 2014).

How the rural social network self-organize and evolve?

In fact, we did not observe any auto-organization on the rural social network at this time.

How trust constraint the network design over time?

The trust is an important feature of the network formation because settled small farmers are more likely to establish and maintain a connection with trusted fellows, including the facilitators, confirming the work of Jana et al. (2013). Therefore, this can limit the pace of the network evolution as stated by Wood et al. (2014).

How the facilitators contribute to the rural social network design?

At the beginning, the facilitators defined themselves as animators of the social network, but not part of it. Nonetheless, the field research showed that they are, in fact, part of this social network and one of the main external sources of new information.

Which are the most relevant social actors (settled small farmers) to the spread of knowledge?

The social actor A1 has the greatest betweenness and this result confirms a long experience of him in the task of spread agroecological good practices.

How fragmented is this social network?

The centrality statistics showed some evidence that this social network might be unbalanced, so suggesting the revision of the facilitator's distribution or the addition of more facilitators to take into account the increasing demand for agroecological knowledge.

Conclusions

The mapped rural social network for knowledge construction in the Southern Rural Territory of Sergipe has a very low index of centrality, is composed of four components, presents homogeneity among the settled small farmers, is heterogeneous in terms of types of social actors, has a limited number of connections between settled small farmers from different settlements, has an almost star structure with one facilitator with the highest in-degree index and with one small farmer with the highest betweenness index. This information suggests that this social network presents an initial good structure for knowledge construction and that the communication between settled small farmers from different settlements should be improved by means of integrating new facilitators considering the spatial distribution of the settled small farmers and motivating the adherence of new settled small farmers.

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