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*Full Length Research Paper*

# Gender and social capital in technological innovation in smallholder systems of sheep production in the state of Michoacán, México

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**Science and technology are important for countries' development, however in order for smallholder (campesino) producers to make use of knowledge, it is necessary to understand social capital and the influence of gender on technological innovation in agricultural systems. This article contributes to an understanding of agricultural technological innovation, using smallholder systems of sheep production in Michoacan, Mexico as a case study. It is an initial theoretical-practical attempt to determine the influence of social capital on innovation. Furthermore, it facilitates understanding how these processes directly affect technological change and lifestyles in smallholder production systems. The capital has an important role in the processes of technology transfer and innovation within systems, social networks, are the aspects that favor further the adoption of innovations through information flows between actors network. Understanding the various factors that influence the transfer of technology and can serve as a basis for the establishment of public policies for the rural agricultural population.**

**Key words:** Social capital, agricultural technology innovation, smallholder systems of sheep production, gender, social capital.

## INTRODUCTION

Technological development has had a profound, positive impact on production, economic growth, employment, the market, the environment, industrial structure, etc. at an international level. Science and technology are considered to be the most effective way to achieve socioeconomic development and growth in developing countries. We can therefore infer that the role of science and technology is crucial, and that scientific knowledge and appropriate technologies are vital for resolving economic, social and environmental problems experienced in developing countries (Ahmed and Stein, 2004).

Nevertheless, the process for knowledge to reach producers in smallholder (campesino) systems has been complicated, and consequently few benefits from science and technology have been perceived in these systems. Some scholars such as Martínez et al. (2004) and Alemán et al. (2003), conclude that technology transfer processes in developing countries involve problems of technical, economic and social adaptability in relation to the economies of production systems. Also, Singh (2003) states that the transfer cannot take place in an isolated manner, but should rather be situated in a social, cultural context that considers human networks of social and economic origin.

One of the main obstacles in the process of adopting technologies is the minimal attention and lack of understanding on the part of development agents toward social variables. It is well documented that the cultural characteristics of national groups, as well as their structures, the occupations of their members, their support networks and their ways of accessing resources are decisive when it comes to adopting technologies (Nuncio et al., 2001; Rigada and Cuanalo, 2005; Monge and Hartwich, 2008). It is also known that small producers have not benefited from new technologies, and one of the reasons is that such techno-

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logies are developed in experimental stations, in which the values and cultures of those who are to use these innovations are not taken into account. The adoption and development of technologies must involve innovation and adaptation processes, in which if adaptation will be beneficial, the technology is adopted and the transfer-adoption process becomes tangible (Rigada and Cuanalo, 2005).

We can therefore affirm that technology transfer is not an isolated act, but rather the product of careful assimilation of knowledge under the influence of the social and cultural conditions of the individuals who use the technologies, with a guarantee of high-level, stable adaptability and efficiency (Martínez et al., 2004). It is vital that producers and their relations with other agents and the environment be acknowledged as part of this process. And this is true even though only three factors of production (land, work and capital) are currently defined in the economy, with a lack of recognition for the human factor, considered by many to be the fourth factor of production (Loria and López, 1999). Furthermore, very few scientific studies have provided empirical evidence of the social factors that determine the different levels of technological adoption in small-scale systems. When the results of these studies are only descriptive, it is not possible to identify guidelines that will encourage decision-makers to consider social factors when carrying out their interventions.

In Mexico only limited studies have been conducted on this topic from an official institutional perspective, given the need to carry out evaluations of programs that subsidize technology transfer, while ignoring producers who are the primary users of such technology. Furthermore, production systems have been traditionally analyzed from a perspective of the technological degree of adoption (high, medium or low), which is only an indicator of the industrialization of production, considering, according to the official version, that systems should manage to reach a high technological level. Nevertheless, this type of categorization does not allow for determining which innovations or how many innovations should correspond to each of the different technological degrees. It is thus a subjective measure for assigning the technological degree that is limited to the criteria of the person using it.

This study is an initial attempt to contribute to the understanding of technological innovation processes applied to smallholder systems, using the sheep production systems in the state of Michoacan as a case study. This study uses a theoretical-practical approach to determine the influence of social capital, through social and gender relationships, in the technological innovation process. The study makes it possible to develop a better understanding of how these factors directly affect technological change in environments considered to be savings and subsistence systems (Bores and Vega, 2003). This study also contributes to an understanding of the mechanisms used by these systems to take ownership of external technologies. This is because, immersed in economies that tend toward globalization, they begin to show signs of changing toward more structured, more intensive production systems (Vilaboa et al., 2006). The findings from this study are useful in understanding how technological innovation can produce positive impacts for the development of sheep production, but primarily in people's lifestyles, thereby creating a useful antecedent for the study of other types of livestock systems.

## MATERIALS AND METHOD

The study was conducted in the outlying areas of the Tepuxtepec dam in the Epitacio Huerta and Contepec municipalities in the state of Michoacan. The sheep populations in those municipalities in 2005 were 16,620 and 21,717 heads, respectively, together reaching a total of 38,337 heads, thus representing 16.2% of Michoacán inventory (INEGI, 2006). The information was obtained from 25 sheep production units operated by women, and 22 units operated by men. These units were family-operated, with semi-intensive production and closely associated with maize cultivation—which means they can be considered to be smallholder production systems.

Since an understanding and explanation of the technology transfer process and the influence of social capital and gender on this process was the main objective of this study, the sample selection was not probabilistic. In selecting the production units to be included in the sample, the availability of producers to carry out this work was the main criterion. With the objective of obtaining reliable information, periodic meetings were held initially, to address matters associated with sheep production, leading to the establishment of trust and signifying that producers shared information with a notable level of veracity.

Information was collected using participative techniques such as interviews, which were used as a basis for designing a questionnaire-type instrument for collecting data. The instrument was validated together with producers, with discussions on its contents during informal meetings. This allowed for the standardization and clarification of terms and concepts between the interviewer and interviewees, thereby avoiding communication or interpretation problems by improving clarity in the use of terms included in the instrument.

Three pilot tests were conducted (with three, six and nine producers, respectively), for the purpose of observing the primary difficulties experienced in the process of communicating with producers, verifying whether the information sought was sufficient and adequate, and avoiding the inclusion of data that expresses nullity in its application. After this part of the work was completed, the instrument was redesigned and its application was initiated, with a single person visiting and interviewing participating producers. All of the above was considered adequate for guaranteeing the validity and reliability of information collected.

### The Variables and the Analysis Considered in the Study were the Following

**Gender:** determined by the person responsible for the system's operations, with the hypothesis that there are differences in the adoption of innovations and that these differences may possibly be attributed to whether the system operator is female or male, given the social and cultural conditions in the Mexican rural setting where these individuals carry out their work.

**Number of ewes in each system:** the number of ewes in each system was considered to be its genetic, productive capital, since production records were not available for observing production dynamics.

Innovations: were identified through a workshop in which producers participated, with the objective of avoiding the inclusion of innovations not used in the region studied. Elements evaluated in the workshop were the use of innovations, the innovation index, the amount of time innovations had been used (years) and their sources of learning. The data obtained were processed through an analysis of frequencies, using SPSS for Windows®.

**Social Relations:** The social relations of the producers were identified, and an analysis of social networks was conducted for the overall group of producers. The size, density and centrality of the group's social network were estimated. With the information collected, the corresponding sociograms were developed, to create a graphic representation of each network and to illustrate how relations occur within the network, based on the directions of interactions. The in-degrees and out-degrees were calculated for the overall network, and for each producer, facilitating the identification of actors involved in the diffusion of information within the network, and the calculation of the diffusion potential. Specialized UCINET® software and its Keyplayer 2 component were used in the data analysis.

Lastly, a multivariate analysis (factor analysis with varimax rotation) was conducted for the following variables: gender, number of ewes, innovation index, in-degrees and out-degrees, using SPSS for Windows®. The purpose was to simplify the multiple, complex relations in the set of variables described above, thus making it possible to examine the interdependence of variables (Pérez, 2005).

## RESULTS AND DISCUSSION

The size of sheep production systems, determined by the number of ewes in each system, was identified as an average of 26 reproducing ewes in the units managed by women, and 37 reproducing ewes in the units managed by men. A high degree of variation was found among producers, with a range from five to 100 ewes per production system. These observations are considered "normal" in this type of system, due to the characteristics of the modes and forms of production, as described (Bores and Vega, 2003).

The results indicate that producers used 16 innovations in their sheep production units, with a high degree of variation in their application. It was found that women use more innovations than men (9.52±2.97 and 5.27±2.08).

Innovations with greater use in units managed by women were health-type innovations (vaccination in 96%, deparasitation in 100%, mineral salts feeding in 96% and vitamin feeding in 88% of units). Administrative-type innovations are used at medium levels (identification of animals in 64% and separation of animals in 52%, as well as the use of production records in 52%), since they require knowledge of how to keep records. The lack of use and application of these control instruments have been considered by a number of scholars to constitute one of the main problems in evaluating this type of system (Nuncio et al., 2001).

In the case of units operated by men, health-type innovations were also most frequently used (vaccination in 90%, deparasitation in 100%, mineral salts feeding in 81%, and vitamin feeding in 59%). This can be explained by the concern on the part of producers' (both men and women) for avoiding illnesses and death—which have a direct effect on the economic situation of the units (Otte and Chilonda, 2000), and also constitute a visible loss of patrimony. The other innovations are used in less than 37% of the units, with the exception of early weaning (Table 1). This coincides with what has been described by Améndola et al. (2006), who conclude that the adoption of new technologies in sheep production systems in central Mexico is low. It is likely that this situation is the result of limited access to training and slow diffusion of scientific and empirical knowledge.

The information indicated that an agricultural technician is the source of learning related to these innovations reported most frequently by both men and women. In the case of women, this is true for 60% of the units. For the units operated by men, the percentage was somewhat lower, with 37.5% identifying technicians as their source of learning. Particularly worth noting is that 30% of male producers report learning from other producers, however in the case of female producers, this innovation was only nine percent. A very low number of producers (16.5% for females and 19.5% for males) reported learning about innovations on their own (Figure 1). Women's behavior in this regard, although not the case for men, contrasts with what was reported by Tapia (2002), who states that technical assistance and consultation services provided to this type of system by specialized professionals have not been as successful as expected. Tapia (2002) attributes this result to a series of factors, such as a lack

**Table 1.** Percentage of innovation use in smallholder sheep production systems operated by female and male producers.

| Innovation | Percentage of Innovation Use | |
|---|---|---|
| | Female producers | Male producers |
| Vaccination | 96.0 | 90.9 |
| Deparasitation | 100.0 | 100.0 |
| Mineral Salts Feeding | 96.0 | 81.8 |
| Vitamin Feeding | 88.0 | 59.1 |
| Grassland Establishment | 36.0 | 18.2 |
| Use of Hay and Silage | 76.0 | 18.2 |
| Diet Preparation | 52.0 | 36.4 |
| Identification of Animals | 64.0 | 9.1 |
| Separation of Animals | 52.0 | 13.6 |
| Records Implementation | 52.0 | 13.6 |
| Controlled Breeding | 28.0 | 9.1 |
| Crossbreeding Definition | 68.0 | 9.1 |
| Early Weaning | 88.0 | 50.0 |
| Intensive Fattening | 8.0 | 0.0 |
| Traditional Method of Steam-Cooking Meat (*Barbacoa*) | 16.0 | 9.1 |
| Composting | 16.0 | 9.1 |

Source: Developed by authors.

of professionalism on the part of technicians; the lack of a business tradition on the part of producers, preventing them from viewing payment for services as an investment; the de-capitalization of farmers, making it impossible for them to pay for services; and the low capacity for response among technicians in relation to producers' expectations. It has also been commented that the efforts of these external agents have an effect on only a minority of producers, specifically on pioneers and innovators who generally pay more attention to new information from external sources (Monge and Hartwich, 2008).

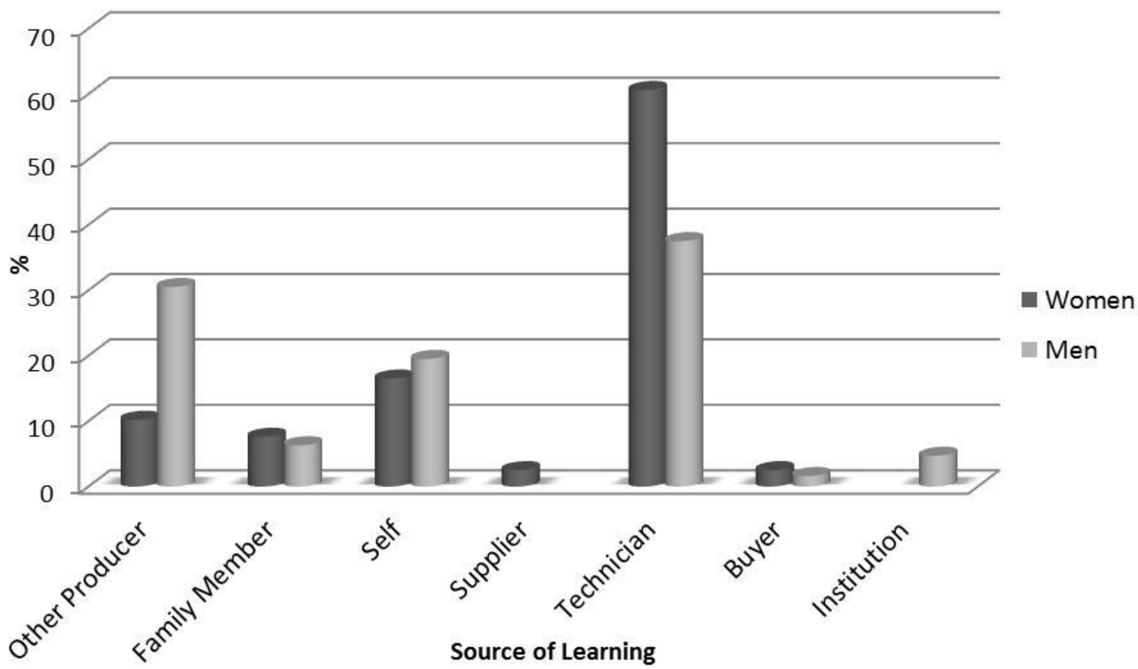
It can be inferred therefore that technicians, as a source of learning for female producers, constitute a very important factor in the technological innovation process. It can be speculated that the difference between genders is due to the skills and abilities that are developed more specifically by women. This also explains the finding that women make more innovations in their systems than men, and that they are more likely to adopt administrative-type innovations, although the level of innovation is low (Jafry, 2000).

The institutions in this sector are mentioned infrequently by producers—both men and women—as sources of learning. Only three percent of male producers refer to institutions as providers of learning. This reveals, as in many other cases, a notorious absence of institutions in the development process (Figure 1). The weak link between institutions and the productive sector indicates that technology transfer follows linear schemes, as described by Tapia (2002) in the case of INIFAP's experience. The latter mentions three major aspects: technological demand, research and technology transfer, in which the aim is to transmit knowledge in a technological package, more than to use production systems to generate and apply this knowledge (Monge and Hartwich, 2008).

The analysis of social networks indicated that in the case of female producers, there is a network of 135 nodes, based on 25 female producers. This is interpreted as low density (3.4%), and can be explained by the reduced average number of female producers' relations.

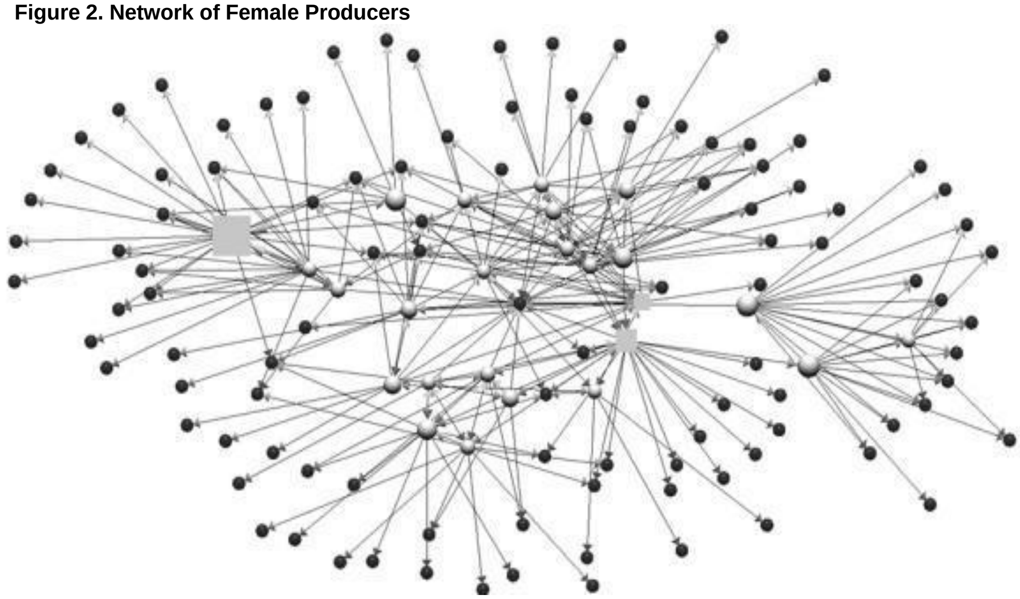
Each female producer has four in-degrees and 11 out-degrees. The 22.5% centrality indicates that the flows of

**Figure 1.** Sources of Learning for Female/Male Producers.




Source: Developed by author.

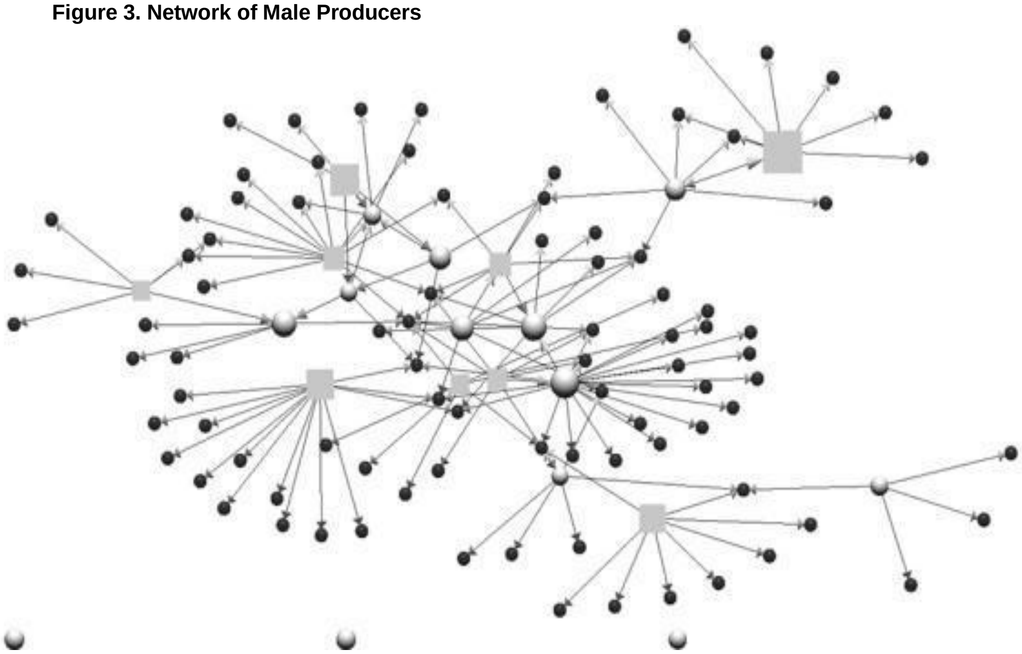
**Figure 2. Network of Female Producers**



Network of female producers (white nodes) and their relations with external agents (black nodes). Node size indicates the number of innovations implemented by the female producers, and a square-shaped node implies the diffusion potential (92% of the network). The network consists of 133 nodes, with 3.4% density, and 22.5% centrality.
**Source:** Developed by authors.

information are concentrated in only a few women. In this case, this signifies that only three female producers are those disseminating information to 92% of the network. This points to the potential ease with which innovations and information can be introduced throughout a network of this type, but there is also risk involved, when the process

**Figure 3. Network of Male Producers**



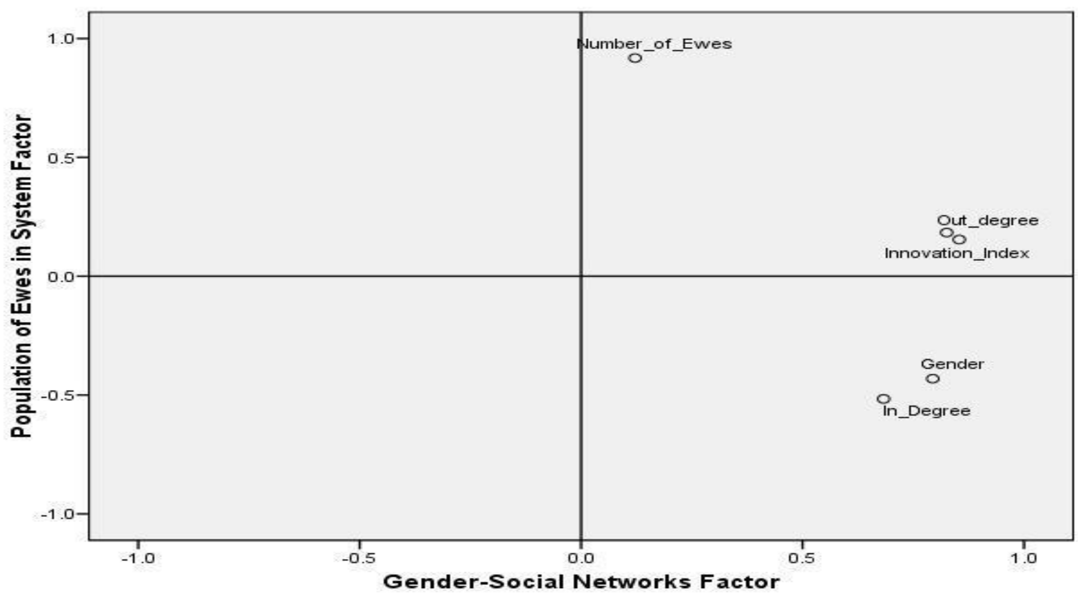
Network of male producers (white nodes) and their relations with external agents (black nodes). Node size indicates the number of innovations implemented by the male producers, and a square-shaped node implies the diffusion potential (91.1% of the network). The network consists of 110 nodes, with 2.3% density and 17.3% centrality.
**Source:** Developed by authors.

depends on only three individuals (Figure 2). It is evident in the social network that female producers interact with other producers, and that they have many of the same external agents, indicating that the information that flows into the network is likely to be more homogenous, since their sources of information are the same (Figure 2). This can be explained on the basis of the fact that informal social networks are important for the dissemination of innovations, including animal improvement and new production practices (Pandolfelli et al., 2008).

The social network formed by male producers is smaller, in comparison with the female producers' network. The network consists of 110 nodes, with 22 producers, 2.3% density and 17.3% centrality. On the average the in-degrees and out-degrees for male producers are one and six, respectively, indicating a minimal flow of information into the network. In addition, the findings indicated that relations are dependent on groups being formed by a producer and his external agents, with minimal interaction with other producers and few cases in which a producer has the same external agents as other producers. It is likely that the information in the network is heterogeneous, since nine producers are needed to disseminate the information to 91.1% of the network (Figure 3). Based on this evidence, we can say that men tend to form groups that are associated with external agents in a particular way. Specifically, each producer maintains his relations with external agents, but very few of those agents are "shared" with other producers. This particular manner of forming producers' groups may be explained by the fact that men are those who tend to have a second economic activity that complements their income and that may be local, regional (migration to other Mexican states) or even international (temporary migration to other countries). Davis and Winters (2008) have documented that in ejidos (communally-owned lands) and rural settings in general, men are more likely than women or young people to leave their families to migrate and seek income for resolving the family's economic needs. This signifies the absence of an important member of the family, and means that decision making and the task of operating the production system becomes the responsibility of the woman in the family, who becomes fully knowledgeable about the system and the problems involved.

This means that, in the case of units operated by men, the limited social relations and smaller amount of time dedicated to production activity leads to a lack of awareness of the problems encountered in sheep production systems. It is likely that male producers seek to compensate for their lack of knowledge through quick observations of other production processes—even though these processes are characterized by different conditions in other systems. These observations and their subsequent implementation by way of imitation do not always lead to positive results, and consequently producers tend to underestimate the potential of technological innovation. This interpretation is supported by the fact that 18% of male producers report learning on their own, and this learning is likely based on observations of other

**Figure 4.** Weight of Factors for Study Variables.




**Source:** Developed by authors.

systems, and not necessarily detailed observations that would tend to motivate an interest in technological innovation through a process of imitation, as documented (Monge and Hartwich, 2008).

Disconnected nodes can also be observed in the network presented in Figure 3. These nodes represent producers who reported not having links with any other actors in relation to their activities. This situation is currently found only very infrequently, since it can be assumed that producers will have to interact with at least one person who buys their livestock or sells them feed or veterinary medicine. What was found reveals two important characteristics of male producers in this type of system, specifically the individual nature of their production activity, and their minimal willingness to provide information to others regarding their activities. This characteristic can be interpreted as an enormous obstacle to carrying out activities together with other producers or with other change agents—in the case of technicians—in order to facilitate a greater flow of information toward the network, and consequently greater possibilities for technological innovation (Rigada and Cuanalo, 2005).

The empirical information gathered indicated that female producers, in contrast to male producers, seek assistance from neighboring female producers in the same community, to exchange information and work to solve problems, as well as to organize shared activities. Some researchers argue that women in general are more altruistic than men, and it is easier for them to participate in collective work for the community's benefit (Pandolfelli et al., 2008). The information gathered revealed that women spend more time in the community, observe the problems experienced in their surroundings, and interact with other female producers in the community, exchanging information and forming groups that allow them access to specialized professional services, providing motivation for obtaining more potential from technological innovation.

An important aspect of technological innovation processes are the external agents who serve as sources of new knowledge, and thus, innovation (Monge and Hartwich, 2008). In this regard, we can observe a greater number of sources of external information in the network of female producers, and we can assume that this facilitates the flow of information into the network. However, it is important here to consider the objectives of external agents when they intervene in these systems. We know that in many cases their only objective is to introduce a certain technology, and create a dependency on the part of the production units to the inputs necessary for using such a technology. This situation presents great risks to smallholder systems, and becomes a disadvantage for the innovation process, as has been witnessed in emerging economies (Carrillo and Chafla, 2003).

In the multivariate analysis conducted, two factors were revealed (explaining 77.8% of the variation in data): a factor referred to as the Population of ewes in the system, determined by the number of ewes (correlation coefficient of 0.9), and another factor denominated Gender-Social Networks. The findings indicate that the components are associated with the following characteristics: social capital (out-degrees, 0.8 and in-degrees, 0.7), technological innovation (adoption index, 0.8) and gender (0.8) (Figure 4). This demonstrates that the technological innovation in this type of system is conditioned by social capital and by gender more than by the number of livestock in the system. One of the hypotheses expressed in this work is that large systems with greater numbers of ewes will tend to be more innovative, since they require greater optimization of resources, but this behavior was not observed in these systems.

The gender roles described earlier are important in relation to technological innovation, and may be changing due to the economic, political and cultural changes documented (Pandolfelli et al., 2008).

We can infer from the evidence presented that for female producers, social relations are important in the diffusion of knowledge, since they have a larger social network characterized by greater density. The observation of a greater number of reciprocal relations indicates that the information within the network may lead to more homogenous technological change, since there is greater learning from other female producers and from technicians. It appears that social networks of female producers are established with other female producers in the community, and this can be observed in their relations and in the reciprocity of these relations.

## CONCLUSIONS AND IMPLICATIONS

Based on the information presented, we can say that social capital is determined by the relations that producers establish with other producers and with technicians for carrying out their activities. Social relations, and therefore social networks, are the aspects that favor to a greater degree the adoption of innovations through the flows of information between actors in the network. There are social aspects such as migration, individuality and the type of work carried out by producers that condition technological innovation in these systems. Technological innovation processes are complex, but even so, it was still possible through this study to largely determine the importance of social capital and gender in the adoption of innovations. Social capital has a major role in technology transfer processes and in the establishment of innovations within systems. If a system's operator is a woman, with social relations established and with sources of technical learning, this can guarantee the rapid assimilation and diffusion of the necessary knowledge for increasing levels of innovation, and consequently, the system's productivity.

This work also brings attention to the need to establish links between those who generate this knowledge and those who use it, to make it possible to establish processes for networking and development in rural settings and for research.

In smallholder systems such as those studied in this case, technological change is influenced to a lesser degree by market prices, which lead to a slow process of innovation in these systems, not allowing their rapid insertion into more intensive production economies. This type of system has nevertheless prevailed and is important for producers, since it is a source of work for them, and generates economic and social satisfiers.

A contribution is made to the theoretical basis for technological change when the need to place more importance on the influence of social capital is reaffirmed, based on information for smallholder systems. It also becomes clear that it is feasible to study smallholder systems and their relations with innovation from a perspective based on lifestyles. This will facilitate and enhance decision-making with respect to rural policies.

Methods such as participative research and trust-generating processes with producers facilitate obtaining indicators and information, and it also assists in influencing the dissemination of information and innovations to smallholder systems.

The tasks of determining the influence of other capitals still remain, specifically the influence of human and physical capitals over technological innovation. An understanding of the diverse factors that influence technology transfer could serve in the future as the basis for establishing public policies in favor of the rural agricultural population, and for establishing practical guidelines for institutions that carry out interventions in these systems.

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