A social network explanation for labour exchange dynamics in traditional and mechanized agricultural systems (the Secano Interior, Chile)

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Hightlights:

1. Personal (Ego-centric) networks were constructed for mechanized and non-mechanized farmers.
2. Denser networks (more links between alters) were found for the traditional non-mechanized farmers group.
3. Older members and closer relationships were found for traditional non-mechanized farmers' networks.
4. Traditional non-mechanized farmers showed a greater dependence on their networks regarding labour availability.

Abstract: This case study explores the structure and behaviour of medium and small farmers' social networks in order to understand how labour exchange plays a fundamental role as a resilience strategy in a highly vulnerable socioeconomic and environmental context as the Mediterranean dryland region of South Central Chile. It also examines social dynamics related to agricultural production, cooperation behaviour and traditional production activities from this particular context. A personal (Ego-centered) social network approach was used to achieve an in depth look into these strategies and behaviour, but especially to explore local social structure. Results show denser networks for traditional farmers in comparison to those using agricultural machinery along with other structural indicators and network attributes supporting greater connectivity for smaller producers. The results also reaffirm the potential of social network analysis in assessing the relationship between agricultural production and sustainability in rural regions with mixed socio-economic systems.

Keywords: Ego-centred networks, Social Capital, Resilience, Sustainability.

Una explicación desde las redes sociales a las dinámicas de intercambio de mano de obra en agricultura tradicional y mecanizada en el Secano Interior de Chile

Ideas clave:

1. Se construyeron redes personales (Ego-céntricas) para productores agrícolas mecanizados y agricultores tradicionales no-mecanizados.
2. Se encontraron redes sociales con mayor densidad (más enlaces entre los miembros) en el grupo de productores tradicionales no-mecanizados.
3. Se encontraron miembros de edad más avanzada y relaciones más cercanas en las redes de agricultores tradicionales no-mecanizados.

4. Los productores tradicionales no-mecanizados mostraron una mayor dependencia hacia su red en términos de disponibilidad de mano de obra.

Resumen: Este estudio de caso explora la estructura y comportamiento de las redes sociales de mediano y pequeños agricultores con el objetivo de entender como el intercambio de mano de obra juega un rol fundamental a manera de estrategia de resiliencia en contextos de alta vulnerabilidad socioeconómica y ambiental, como lo es el secano del Mediterráneo del Centro Sur de Chile. También examina dinámicas sociales relacionadas a la producción agrícola, comportamientos de cooperación y actividades tradicionales productivas presentes en este contexto particular. Un enfoque de redes sociales personales (Ego-centradas) fue utilizado para lograr una vista en profundidad de estas estrategias y comportamientos, pero especialmente, para explorar la estructura social local. Los resultados muestran redes sociales más densas para productores tradicionales en comparación con aquellos usuarios de maquinaria agrícola junto con otros indicadores estructurales y atributos de redes, sosteniendo una mayor conectividad para pequeños productores. Los resultados también reafirman el potencial del análisis de redes sociales en evaluar la relación entre producción agrícola y sustentabilidad en regiones rurales con sistemas socio-económicos mixtos.

Palabras clave: Redes sociales ego-céntricas, Capital Social, Resiliencia, Sustentabilidad.

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Introduction

Social interaction is so important that research suggests social isolation and exclusion may cause physical pain, this is because physical and social pain operate via common mechanisms (MacDonald & Leary, 2005). There has been a long and continuous debate about why social relations are so important, some theories argue that social relations are mainly instrumental (Lin *et al.*, 1978), meaning that humans seek to establish relations and cooperate with others looking for "material" rewards, while others argue that a series of factors such as emotional connection, identities, common values, trust, among others, makes the need to "belong" purely social (Tyler, 2011).

Although studies about social cohesion and cooperation focusing on urban neighbourhoods are predominant, there has been a significant literature development focusing on rural areas (Wynne-Jones, 2017). Particularly interesting are the efforts to explore social structure in this type of contexts (Fu & Hao, 2018), since this is the foundation for understanding social capital dynamics, especially related to agricultural production.

As Coleman (1988) explains, social capital is defined by its functions, it is not singular, but a variety of different entities, having two elements in common: all have some form of social structure and assist actors (people or groups) to perform certain actions within the structure: "Like other forms of capital, social capital is productive,

making possible the achievement of certain ends that in its absence would not be possible" (p. 98). It is by this principle that social groups encourage social capital creation to facilitate the coordination and cooperation in order to generate mutual benefits (Putman, 1993). It has been documented that social capital promotion through the interaction between neighbouring farmers has positively influenced productive practices (Compton & Beeton, 2012) and how informal institutions in the form of peer networks has channel efforts in production and resource management (MacGillivray, 2018).

In mid-twentieth century the anthropologist Radcliffe-Brown (1940) pointed out that it is through direct observation that we are able to observe how human beings are connected by a complex network of social relations, this is what he called "social structure". However, when these networks are put into action in a particular context, these relations create something that can be valued. Although, there a multiplicity of ways to conceptualize and measure it (Portes, 1998), this is a classical approach to understand social capital through the base provided by social structure. Summarized by Entwisle *et al*. (2007) as "the social organizational components that can be used by individuals or groups for undertaking certain actions" (p. 1499).

In multiple production contexts, and especially in traditional agricultural systems, this type of social capital has been addressed as "co-operation". Sennett (2012) defines it as "an exchange in which participants benefit from the encounter" (p. 5). Agricultural co-operation has evolved during its long history of farmers coming together, from mainly labour needs to more complex types of aids and political movements (Wynne-Jones, 2017). This type of interaction converges in formal and informal associations with agreements and even sometimes contracts, but that are, in most cases, regulated by social norms and expectations (Dias & Franco, 2018).

As presented before, labour co-operation is one of the most elementary ways of social capital applied to agricultural production. Although labour can be compensated by multiple means, labour exchange appears as the most fundamental way labour is reimbursed (Wilk, 1991). Labour exchange practices sustained on networks of social capital and principles of solidarity and reciprocity can be found all around the world. It has been documented in multiple regions of Africa (Shiraishi, 2006) to Java (Koentjaraningrat, 2009), Thailand (Tsurata, 2005), Sri Lanka (Tilakaratne & Somaratne, 2002), Japan (Suehara, 2006) and Latin America (Wilk, 1991).

As explained by Subejo & Matsumoto (2009), labour exchange is "characterized by mobilization of labour under rotational system among involved parties" (p. 3932). A key unit in this rotational system is the household (Wilk, 1991) which relies in

kinship, friendship and neighbourship for particular production tasks that would be particularly difficult to accomplish on their own, and also, are key for the household survival (Cox, 2008). This network stablishes a family support system (Tsurata, 2005) which according to Rodriguez & Salas (2010) is entailed in the conception of peasantry: "Their traditional practice themselves constitutes a means of social capital, or communitarian social capital that defines them" (p. 49). For the authors, the existence and exercise of social capital and cooperation is the main characteristic of being peasants and most importantly; it defines and attributes an identity (Ibid.).

However, the economic, sociocultural and environmental context is not static and is continuously evolving, and therefore, social structure also adapts to these transformations. This is particularly relevant in rural settings where traditional agriculture is sustained primarily by labour exchange. As pointed out by Wynne-Jones (2017) there is a constant friction in the western society where individualism is promoted and opposed to collectivism. This friction is particularly noticeable in the rural world through the implementation of technological innovations, which interacts with society during its diffusion process having economic, cultural and political implications (Haenssgen & Ariana, 2017).

These implications turned out especially relevant during the execution of the "Green revolution program" during the 1960's and 1980's (Pingali, 2012) all around the world. Subejo & Matsumoto (2009) found that in Indonesia this particular program had great effects on local traditional labour exchange networks. They notice that, although rural communities have some capability to adapt to the influence of external factors as technology introduction, certain kinship, neighborship and friendship networks were weakened, resulting in the "deterioration of labour exchange practices in many communities" (p. 3934).

This deterioration plays a complex relationship with the process of rural out-migration. It has been showed that co-operation networks are generally more efficient with larger number of members (Hiwatari, 2016), having out-migration as a relevant issue for rural communities by putting pressure on the remaining members of the network to maintain current production standards. Although, it is known from extensive literature that the ongoing process of rural-urban migration is the result of multiple socioeconomic, political and environmental factors, the effects of transformation of social structure through the weakening of labour exchange and co-operation networks could be playing a key role in this vicious circle. This is because agriculture, in its essence, is social; it relies on social interactions and its embedded in society.

One of the main ways in which social interactions and social capital is registered, quantified and assessed in the current scientific literature is through social network analysis (SNA). This is due to the fact that structural social capital is organized and put into action through these durable networks with more or less institutionalized relationships (Bourdieu, 1986). Social networks are capable of showing reciprocity patterns and can serve as a model for collaborative achievements (Putnam, 1993).

Among the various approaches used in SNA, personal or egocentric networks have proven to be particularly useful for the study of social support, especially in contexts of high socioeconomic and environmental vulnerability (Wellman & Wortley, 1990). This is because personal networks are a main component to understand local social structure, which along with its relationship with social processes can unveil key exchange dynamics (Bodin & Crona, 2009).

The social network approach has an enormous potential in assessing rural communities' vulnerabilities and the process of resilience building (Wilson *et al.*, 2013). This is because the adaptive capacity of these groups resides in social networks, these structures are able to "buffer, adapt to and shape change by providing resources needed to cope with external stresses and disturbances" (Rockenbauch & Sakdapolrak, 2017: 1). This is critical in the context of New Rurality, where the plasticity of social institutions, landscapes and markets are resulting in new ways of adaptation. An example of this is the emergence of translocality, this concept challenges dichotomous geographical conceptions such as rural/urban or core/periphery. SNA has proven to have the tools for looking into the simultaneous embeddedness of social actors in "translocal networks" (Jessop *et al.*, 2008) which is also a resilience response (Adam-Hernández & Harteisen, 2019).

Research from SNA has also shown how agricultural social networks play a key role in socio-ecological sustainability (Janker *et al.*, 2019), especially in the process of adaptation to climate change (Abid, *et al.*, 2017). Here collaboration at the local level showed to be "more effective than individual efforts to enhance the adaptive capacity and resilience in the agriculture sector to climate change" (Ibid: 2). Not only that, research has also shown the importance of local social networks in the execution of resource-conserving agriculture, but especially, in spreading of sustainable practices through key actors or network nodes (Nyantakyi-Frimpong *et al.*, 2019). Social capital in agriculture is not only relevant concerning adaptation and conservation, but it is also a key factor to consider in any restorative effort. According to Swagemakers *et al.* (2018) a cooperative approach is a starting point in any ecological transition to sustainability.

Socio-political and historical background

The history of agriculture in Chile is the history of overexploitation and inequality. With the arrival of the Spanish *conquistador* during the sixteen century a strong process of occupation and displacement of the indigenous Mapuche started from north to south. Although the Mapuche were engaged in slash-and-burn and small cropping activities, their agriculture was conducted mainly on valleys and plains (Bengoa, 2003). On the other hand, European methods and technology brought by the Spaniards enable a, not only, more intensive, but also, more extensive agriculture, reaching land with higher slopes and vulnerable soils (Mellado, 2007). The socio-economic and environmental implications of the 300-year Spanish occupation began to be recognized by Ignacio Domeyko and Claudio Gay, two European naturalists, ecologist and geologist hired by the Chilean government in 1837. For the south-central region, Gay explains in his "Agriculture history of Chile" that the plough became the cornerstone of the Chilean agricultural revolution, which totally changed the industry and the landscape (Gay, 1862): "The capacity to produce in much more extensive areas led to the manifestation of the *conquista* as an essentially agricultural *conquista*" (Ibid: 13). The impact of the plough was so massive that the region began to produce more food than needed, according to Gay this led to monotony and very low prices, with a practically zero national and transnational trade. This status remained for decades until 1687 when a massive earthquake shook Lima, Peru. Bringing sterility in terms of production in the adjacent supplier regions, the production ostensibly decreased. In this scenario an important part of the Peruvian population was suddenly deprived of wheat for primary consumption, and they were forced to turn to Chile (Gay, 1862: 17). This event, which later was labelled as the first Chilean economic activation, allowed a trade system that did not exist in the past, but also implied the productive activation of new provinces, as the Mediterranean region. In this new context, colonial Chile had a new economic goal, this led to the agricultural exploitation of "new" areas that had not been largely intervened.

However, this new scenario did not last forever, and along with the productive recovery in Peru the Chilean economy began to stagnate again. The *haciendas* continued producing the same flow rate and the diversification of the market minimal. According to Gay (Ibid.) this situation did not change until another historical event; the war for independence. This time the economic lifesaver did not came from a natural event, but from a socio-political one, the war against Spain fuelled the

economy, generating new needs and market movement with a momentum that lasted through the peace restoration.

During this period of independency many bourgeoisies *criollos* travelled to Europe in order to learn this new "Agricultural Sciences" and also to buy and bring back to Chile agricultural machinery in order to boost production, for example different types of modern and more mechanized ploughs (Ibid.). This was the genesis for a new political-economic national approach, a new paradigm in the way producers related to the environment. The introduction of these new methodologies and technologies led to the exploitation of most of the forest in South Central Chile (Camus, 2006). In most cases they were burned down to make space for wheat production which became the main foundation for the current soil erosion and land degradation issue in the region.

The agricultural production grew even more; "Many villages and small towns were established because of the wheat production" (Mellado, 2007: 21), there was a time when wheat was even used as an exchange currency: "Minister Waddington, an important farmer from the Aconcagua Valley, stated in 1852 that Chile could conquer the global wheat markets due to low production costs and high yields" (Keller, 1965 in Montaldo, 2004). A fraction of this phenomenon was promoted by the saltpetre mining in the North of Chile, however as explained by Arancibia & Yávar (1994) and David (1993) in Mellado (2007) the main- historical event that fuelled this new revolution was the Californian (1854-56) and Australian (1864-1866) "gold rush". Here a tremendous amount of migration and mining settlements required huge amounts of food, mainly wheat. According to Montaldo (2004) wheat export raised to a million quintals, with a production surpassing the four millions: "without a doubt, Chile had become a grain grower country" (p. 62).

The final historical event in this timeline is the "Green Revolution". This term coined by the Director of the US Agency for International Development (USAID) has been globally described as "technological improvements – in seeds, fertilizers, and pesticides, along with enhancements in irrigation and other mechanization processes – developed to increase agricultural production" (San Martin, 2017: 779). This process of agricultural modernization has been surrounded in a narrative of success, however research has shown a series of environmental externalities and socio-economic issues associated to it (Shiva, 1991; Perkins, 1997; Pearse, 1980).

Since the 1960s Chile was preparing the institutional structure to execute a plan to modernize agriculture with the support of USAID, the Rockefeller and Ford Foundations (San Martin, 2017). However, the 17 year-long dictatorship lead by Augusto Pinochet and its violent restructuration of the Chilean politic and economic

system was the perfect context for the implementation of the needed reforms for the "Green Revolution" blooming. This included the "efforts to boost food production through mechanization, organize landholders into cooperatives, and develop greater access to agrochemicals such as fertilizers and pesticides" (Tinsman, 2014: 38 in San Martin, 2017: 784). However, the military regime did not benefit every productive stratum similarly, blocking resources in form of assistance, credit, machinery and infrastructure to the small subsector. This agricultural policies has been linked to the high levels of inequality in rural Chile (Gwynne & Kay, 1997).

Along with this economic inequality, Kurtz (2004) explains that the establishment of agrarian capitalism in a sector of the economy where it had not before existed implied the building of a new rural social structure. In comparison to the urban context, where the economic reform meant "the freeing of long extant and comparatively well-functioning markets" (p. 51), in the rural areas the foundation of the market economy (individual and alienable property rights, free labour contracting, and free price setting (Ibid.)) had to be built largely from scratch. Even more relevant for this research, according to Kurtz; this process transformed rural social and associational life: "As markets were created, so were individuals: shared interests and collective action were replaced by organizational decay, conflicts of interest, social differentiation, and the emergence of a peasant *homo economicus*" (p. 52). Finally, Kurtz concludes that the most critical impact provoked by neoliberalism in the rural areas of Chile was to: "Undermine the associational networks (both formal and informal) that had historically characterized rural community life. This transformed the question of group political participation and interest aggregation into a one-off prisoner's dilemma – and free riding replaced cooperation as the order of the day even where shared interests survived" (p. 53). The theoretical and ideological principle of "individualization" behind the capital and the neoliberal system is a key component that links the past with the present, the global with the local.

Materials and Methods

Study area

The *Secano Interior* (Interior Dry-land) is located in the Mediterranean region of South Central Chile. This region is characterized by cold and humid winters and

dry/warm summers, having anthropogenic savannas as the main ecosystem in the unirrigated portions of the sub-humid and semiarid regions (Ovalle *et al.*, 1990). Forest plantations (pine and eucalyptus) have also a key role in the local landscape configuration, occupying more than 46.000 ha in the Biobio administrative region (CONAF, 2017). It is also important to highlight the topographical profile of the region, here the *Secano Interior* is located where a longitudinal central valley meets the coastal range (Casanova *et al.*, 2013). This topographical feature is significant because the interaction between hilly areas and valleys have implications on labour exchange dynamics (Subejo & Matsumoto, 2009), especially concerning differences in agricultural machinery use due to socio-economic and biophysical factors, as slope and soil quality (Infante, 2017).

The region is also loaded with a history of environmental degradation sustained in a systematic process of deforestation in order to clear land for cereals production. This resulted in serious soil degradation issues for a large amount of the territory and the consequential aggressive introduction and expansion of introduced monoculture pine and eucalyptus plantations (Reyes & Nelson, 2014).

The Mediterranean region also clusters very diverse cultural and socioeconomic configurations attached to the territory. For example, there is the wine industry, consisting mainly of big producers, owners of the best land and good access to irrigation water. On the other hand, there are small farmers' communities traditionally producers of wheat and other cereals. Most commonly living in the cheapest and much more degraded land, and in many cases struggling for irrigation water. These communities are characterized by high levels of socio-economic vulnerability and facing a drastic process of depopulation during the last decades (INE, 2008).

Previous ethnographic research conducted in the region shows the progressive dismantling of traditional cooperative networks through agricultural mechanization and monoculture forestry expansion (Infante, 2017). Social capital was mainly mobilized through trust and labour networks materialized in productive ceremonies as "*mingacos*" (cereal sowing and harvesting) and "*vendimias*" (wine grapes harvesting). These gatherings work reciprocally relating hosts and guests *vice versa* in a network of labour interchange. These networks are critical for the more vulnerable households, allowing small producers to accomplish demanding (economic and physical) production tasks which could not be achieved without the aid of the community and therefore becoming dependent to the network (Ibid.). The expansion and encroachment of rural communities by monoculture tree plantations and the mechanization of agriculture through rural extension policies and projects that

disregard social capital networks and their importance in rural social structure intensifies labor scarcity and rural depopulation (Hecht, 2010; Prayitino *et al.*, 2014).

Figure 1.
shows a map of the Biobio administrative region, the Secano Interior and the study site:

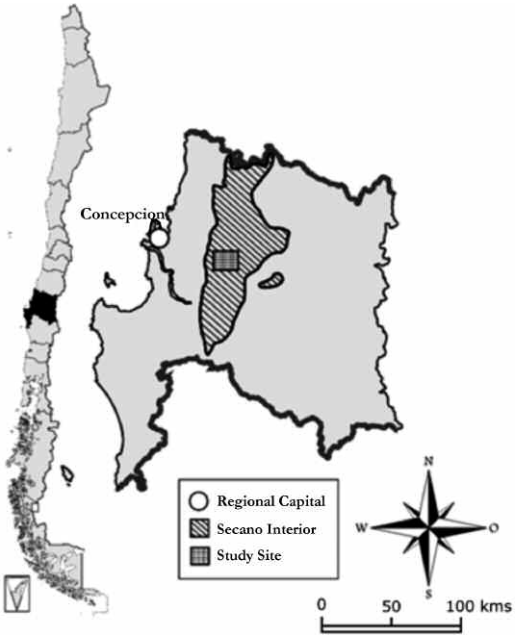


Figure 1. Study site located within the Secano Interior and the Biobio administrative region of Chile.

Methodology

This case study is part of a research concatenation conducted by the author in the region, focused on social capital dynamics and its implications on local economy, environmental characteristics and social structure. In a previous study (Infante, 2017) a purely qualitative approach was used to unveil the background mechanics of labour exchange and cooperation in the region. Considering that, the present research is outlined as an exploratory study (Zimmerer, 2004) entirely focused on local social

networks from a quantitative approach. In order to achieve this, the method used was a personal network survey (McCarty *et al.*, 2007), this type of personal (ego-centred) network survey and its analysis allows to quantify, and especially, visualize the respondents' networks and their attributes. These networks captures "an individual's definition of the individuals connected to him or her by specified social relationships (Bernard, 1998: 712)". However, these networks involve more than pure relationships, they also contain attributes (age, gender, tie strength, occupation, etc.) of the network members along with characteristics of those networks themselves (density, closeness, etc.) that can be incorporated into network profiles (Idem.)

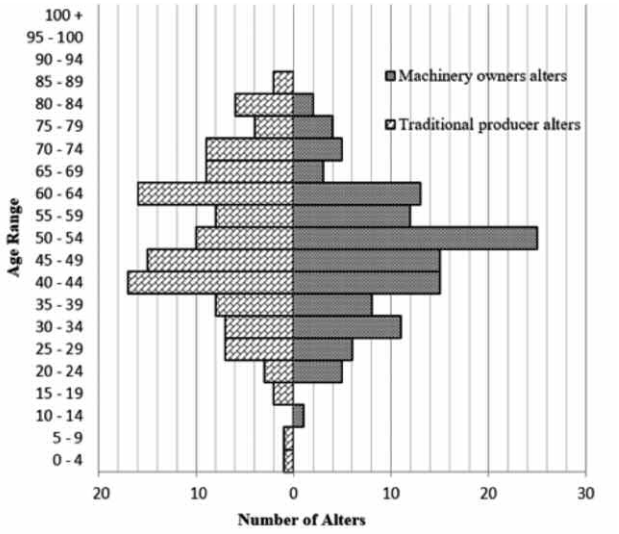
Respondents were contacted through local informants (community leaders) and through a snowball sampling, which is a non-probabilistic sampling technique used to promote that existing study subjects propose future subjects (Goodman, 1961). The resulting sample consisted in 10 respondents (5 traditional producers and 5 machinery owners) who were approached at their houses and asked if they were interested in participating in this research. An official ethics clearance was filled by the respondents explaining the two parts involved in the study (socio-economic and network survey).

All personal network data was elicited and collected verbally but was entered directly into Egonet software using a laptop computer as the informant responds to minimize potential researcher error. As explained by McCarty *et al.* (2007: 148) this software is designed as a "questionnaire authoring language that allows researchers to tailor the interview to their specific research interests" and consist of four modules: 1. Question asked of the respondent about themselves. These were 18 questions focused on basic socioeconomic data (gender, age, marital status, location, offspring, household occupants, main economic income, property ownership, property size, agricultural knowledge, labour needs, development program participation, etc.). 2. Questions used to generate the names of network alters (n=25). 3. Questions asked to the respondent about those alters. These were 10 questions generating network attributes (Gender, age, location, main economic income, how close they are, how they know each other, for how long, how frequent they see each other, participation in some form of labour exchange, machinery ownership). 4. Questions asked of the respondent about the existence of relations between alters (E.g. Does A knows B? Does A knows C? Etc.). The Egonet software is an essential tool not only for the collection of network data, but also for the analysis of this data. It is important to point out that the number of ties grows geometrically as alters are added, in the case of the present research of 25 alters, there were 300 alter pair evaluations (). By this the respondents are asked to evaluate a set of "binary relationships that are then built into a representation of personal network structure" (Ibid: 146).

Results

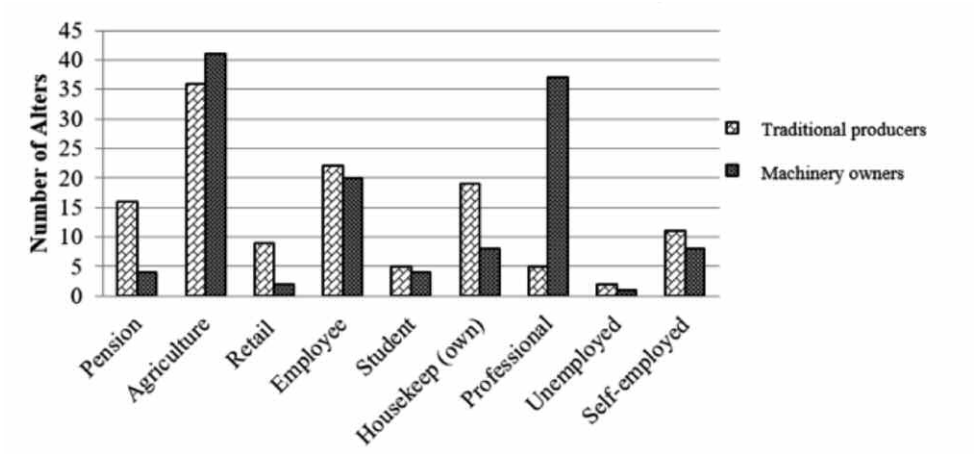
The ego-centred networks shows some interesting characteristics in relation to alters' (network members) attributes. In relation to age, which is an important factor concerning production and labour, machinery owners' alters have a slightly lower age average (48.18 years) in comparison with traditional producers (50.36 years). However, looking at the age pyramid visualization in Figure 2 it is possible to notice how the machinery owners alters are mainly situated in the middle age range section, especially in the 50-54 years. On the other hand, in the traditional producers' side, the upper age range section stands out with a stronger representation, especially from 60 to 90 years. This could imply a larger amount of alters in a work/productive age for the machinery owners, while a larger amount of retired people in the traditional producers' networks.

Figure 2.
Networks alters age pyramid for machinery owners and traditional producers



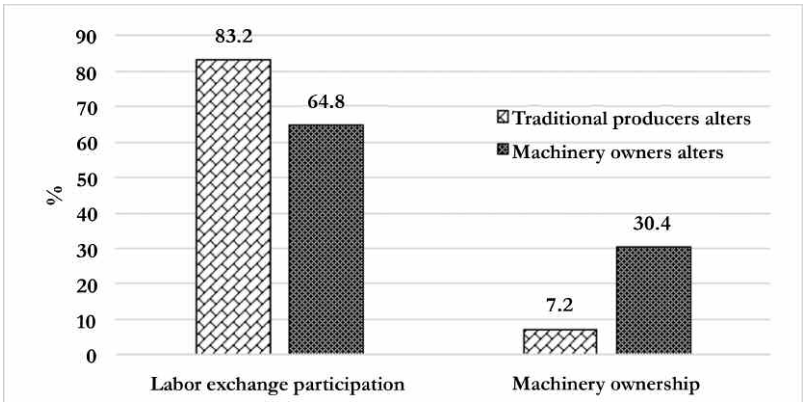
Another relevant factor for agriculture labour exchange dynamics is the network members' occupation. Almost 31 % of all alters have agriculture as their main economic activity, with a minimal dominance for the machinery owners alters'. Along with this, the main gap between the two groups can be found in the number of professionals (with a college degree) in the network, having machinery owners surpassing for more than seven times the traditional producers' networks. This former groups also leads on alters with retirement pensions as main income which correlates with the age results shown in Figure 2. Network member occupation breakdown can be visualized in Figure 3:

Figure 3.
Network alters' main economic activity by group.



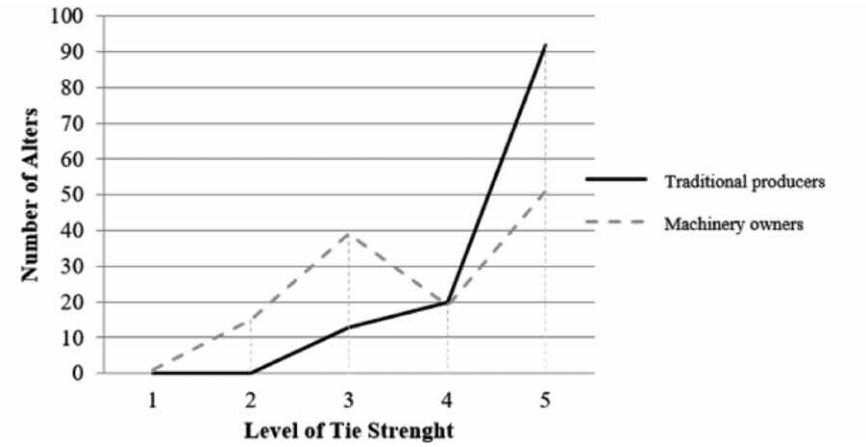
One of the most relevant network attributes for this study is the number of alters that participate in some sort of agricultural labour exchange dynamic. These are mainly materialized in community events during planting and harvesting season of both cereals (*mingaco*) and wine grapes (*vendimia*). Is interesting to see that for both groups, this type of participation is considerable high with 64.8 % of machinery owners' alters and 83.2 % for traditional producers. As also can be noticed in Figure 4, the percentage of alters owning machinery is significantly higher for respondents that own agricultural machinery as expected.

Figure 4.
Percentage of alters participating in labor exchange and agricultural machinery owners.



Finally, in terms of network attributes, one of the key elements in any network, especially in the context of cooperation, is the tie strength between the respondent (ego) and alters. Here, for each alter added the respondents were asked to grade "How close they feel to each person in their network". For this, a scale from 1 to 5 was used, where a 5 score meant a "Very close" relationship (kinship is included in this score) to "Not close at all" for a 1 score. The resulting graph (Figure 5) illustrates how traditional producers' networks presented a much higher number with high tie strength compared to machinery owners. This is especially notable for ties with score 5 (Very close relationship) almost doubling the numbers of alters in machinery owners' networks.

Figure 5.
Tie strength for network alters in traditional producers and machinery owners.



Along with network attributes as age, occupation, tie strength, among others, a fundamental approach to explore and compare these two groups' networks is through their structural metrics. One of the most relevant of these metrics is network density; it represents "the percent of ties that exist in a network out of all possible ties" (McCarty, 2002: 4), with 1 denoting networks where everyone is connected and 0 for a network where nobody is connected. In this respect there is a significant difference between the two groups, having traditional producers with an average density of 0.9 and machinery owners with 0.58.

Along with density, measures related to centrality are essential to understand structure in personal networks (Marsden, 1990; Costenbader & Valente, 2003). Here the emphasis is set on three main measures; the first one is degree centrality, this is the number of alters that any given alter is directly connected to. The second one is closeness centrality, this is the inverse of the sum of the distances from that alter to all other alters. Finally betweenness centrality is equal to the number of shortest paths (or geodesics) from all vertices to all others that pass through that node. Also, the average number of cliques were considered, these are the maximally completed subgraphs in each network. Table 1 shows the average results for each of the above mentioned metrics divided by the type of respondent:

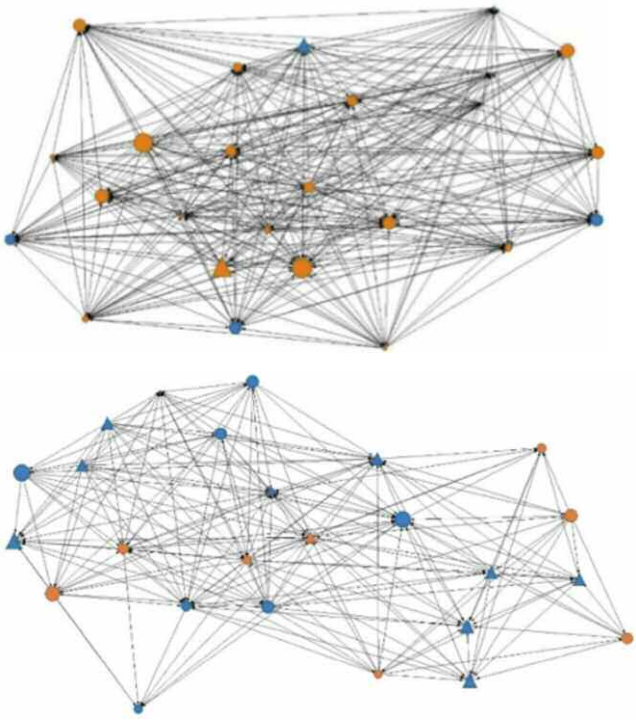
Table 1.
Average network structural metrics for traditional producers and machinery owners.

Network Structural Metric	Traditional Producers	Machinery Owners
Average Density	0.9	0.58
Average Degree Centrality	21.79	13.85
Average Closeness Centrality	93.24	71.07
Average Betweeness Centrality	1.1	5.48
Average Cliques	6.2	20.2

For all these metrics, results show higher values for traditional producers' networks, and therefore, presenting them as much more connected than machinery owners' networks. The average betweenness centrality results are consistent with this, where a lower value means that there are less nodes acting as needed bridges between other nodes due to high amount of connections within the network.

These structural results can also be anticipated just by looking at network visualizations for these two groups. Figure 6 shows the median network for each group according to density measures. Along with presenting structure, these visualizations show other network attributes as age (node size: the bigger the node, the older the alter), gender (node color: orange for females and blue for males) and machinery ownership (triangle meaning ownership and circle no ownership). As it can be appreciated, there are much more links or connections between the alters in the left network (traditional producer), this means that more people in the network knows other people in the network.

Figure 6.
Network visualization comparison
(Above: Traditional producer and below: Machinery owner).



Discussion

Social structure is a relevant factor to consider while researching production, labour, technology and socio-ecological sustainability. This is especially true in the rural context of developing countries where production is strongly sustained by social capital networks. One of the main finds in this study is that, for the *Secano Interior*, both types of production (traditional and mechanized) rely on some kind of cooperation between community members; family, friends and neighbours. However, traditional agriculture is completely dependent on this type of social capital, without

labour exchange and cooperation it becomes categorically non-viable. This co-dependence has been built in time through labour reciprocity, the "unpaid" labour provided by neighbours, and the community in general, is what sustains the traditional production system for many households. This is particularly relevant for high labour-demanding activities as the planting and harvesting where the community participation is critical, therefore it is summoned through events as the *mingaco* and *vendimia*.

Age is probably one of the key factors in this dynamic, traditional agriculture is primarily conducted by older adults, while younger generations have turned into other economic activities, working for larger producers (agroindustry) or migrating to urban settings. On the other hand, households with the economic means and land characteristics (better soils, less slope, irrigation) suited for mechanized agriculture have middle-age man in charge of the main production activities, in many cases retiring the older generation from most economic responsibilities. This can be noticed in the data, having 50-54 as the most representative age segment for mechanized producers.

However, any of the variables observed can be single out as determinant, this is especially true for the presence of machinery owners in the respondents' networks. In some cases, traditional producers had alters owning productive machinery (7.2 %). Although, respondents (Ego) that owned machinery had a much representative number of alters owning machinery (30.4 %) in their networks. In both cases is interesting to find an important number of alters owning agricultural machinery, especially taking into account that the respondents were asked to name any type of contact, not only people engaged in agriculture, where especially for the machinery owners group, many network alters live outside the region and in urban settings. This is also related to the alters' economic activity, with a high number of professionals (mainly engaged in non-agricultural activities) in the machinery owners group.

In relation to tie strength, the correlation between high participation in labour exchange and strong ties seems to constitute the basis behind traditional wheat production in the *Secano Interior*. This relationship is also strongly linked with Portes' (1998) concept of social capital as "the ability of actors to secure benefits by virtue of membership in social networks or other social structures" (p. 8). This sense of membership or belonging is constructed by kinship but also by time. Yet again, is important to avoid a dichotomist idea of associating higher social capital only to more vulnerable human groups, small traditional farmers in this particular case, and higher economic capital to less vulnerable groups. However, in socio-environmental settings of high vulnerability, like some regions of the *Secano Interior*, strong social capital networks are mandatory for subsistence.

In the last three decades, this vulnerability has made the *Secano Interior* a key target of rural extension initiatives and development programs. The introduction of machinery banks in farmers' communities to promote modernization and efficiency in production has been one of multiple strategies to face rural poverty. However, in most cases these initiatives are not putting enough attention on the complexities behind local social structure, social capital dynamics and labour exchange networks. These complexities define a very thin line where intervention can result in the encouragement of competition instead of the promotion of cooperation. This is a critical factor concerning socio-economic and ecological sustainability.

Conclusions

The *Secano Interior* of South Central Chile encapsulates some very particular historical, environmental and socioeconomic characteristics. This interaction implies a high level of complexity in the endeavour of understanding social configuration in these rural communities. The main goal behind this study was to tackle this complexity through an unprecedented approach for this particular site; social networks. Although it was designed with an exploratory perspective, the data shows some interesting outcomes. Ego-centred networks presented two well defined producer profiles. In one hand, machinery owners are not as dependent on their networks for agricultural production as traditional producers. This is expected in terms of how labour is structured in these two settings, having implications in their network age, gender and occupations. Traditional agriculture is becoming progressively unsustainable, not only economically, but especially from a labour point of view. Outmigration, the loss of community gatherings and higher urban salary standards are diminishing traditional producer's workers pool, making them more dependent to other older adults, mostly pensioners with lower production capacities.

This labour factor has implications in the network composition of both groups, but especially on structure. The historical socioeconomic and ecological vulnerability of *campesinos* communities have shaped their personal networks in very dense webs, where not only most people know most people, but also, they have close and very close relationships, creating significantly strong ties. These high-density/high-centrality networks are a legacy from the old times of intensive traditional agriculture

to a new rurality of highly mechanized production for a much specific group, with less dense networks, but higher income and larger properties.

However, the loss of traditional agriculture is a problem. This is because besides the economic aspect, if conducted in a sustainable way, it can play a key role in facing sociocultural and environmental rural issues. For example, in practical terms for conservation, traditional agriculture contributes in "preventing the risk of fire, continuing employment and preserving traditions in rural areas" (Colombo & Perujo-Villanueva 2017 in Dias & Franco, 2018). From a more general point of view, this approach has the potential to become a restorative tool towards more sustainable and diversified productive systems. This, according to Horlings *et al.* (2018), requires a combination of cooperative and place-based approaches focus on the "socio-spatial connections which frame farmers' strategic actions" (p. 246).

In terms of limitations is important to point out that, for a small sample case study, a purely social network approach cannot expect to reach a very deep level of complexities and to encompass the large diversity of factors contributing to this complexity. This is why the present study was articulated as a next step towards the understanding of the complexities surrounding social capital and labour exchange in rural Chile, having in consideration the wide spectrum of previous research on the topic, both quantitative and qualitative. According to the available literature there has been no studies looking into egocentric rural networks in the region. This also implies issues and challenges, having respondents not being used to answer questions as those asked in this research concerning their own support networks, while interviews and surveys (agrarian census) about their social and productive behaviour being quite common for local respondents.

On the other hand, although social network measures have been shown to be relatively stable over time, they are still a snapshot of dynamic reality. This has to be particularly considerer in the context of new rurality (Rodríguez & Salas, 2010; Hecht, 2010) with dynamic processes of mobility, change, and technological empowerment. Once again, a qualitative contextualization is key to understand the externalities involved in complex and shifting socioeconomic, environmental and demographic phenomena.

Future orientations

As future directions from this study, it is possible foresee that the network approach in rural settings can be especially advantageous to find key actors that in

most cases act as bridges between different types of stakeholders, households and communities. Understanding what makes them central to the local agricultural networks can help us identify which practices are being promoted and spread. From this perspective, key actors are not only essential from a structural point of view, but also in terms of knowledge sharing. The study of this process of local knowledge transfer, and its effect on the network resilience in the context of natural resource degradation and climate change, is a research path that should be addressed. Local networks and their key members can become a tangible alternative for local programs to promote new sustainable knowledge without compromising and fostering the local social structure, collaboration dynamics and social capital.

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