Introduction to Social Network Research: Application of Social Network Analysis in Extension[1]

Anil Kumar Chaudhary and Laura A. Warner[2]

Introduction to Social Network Analysis

Social Network Analysis (SNA) is an innovative approach Extension professionals can use to understand interactions among Extension clientele. SNA can be used to define and describe society and its organizations and to assess the impact of various organizational structures (Zack, 2000). SNA is composed of both analytical methods (statistical procedures) and substantive social science theories over and above ability to produce visual network maps to analyze the characteristics of actors (e.g., Extension clientele) and their relationships (e.g., friendships) with other actors in the network (Scott & Carrington, 2011; Springer & de Steiguer, 2011). This publication introduces Extension educators to possible ways to apply SNA in their work to plan and evaluate programs in a more efficient way.

Social Networks

Networks are "a set of nodes and the set of ties representing some relationship, or lack of relationship, between the nodes" (Brass, Galaskiewicz, Greve, & Tsai, 2004, p. 795). Nodes, or actors, are the units of analysis in SNA and may represent individuals, groups/communities, organizations, or countries (Zack, 2000). Relationships define the connections or flow of material or non-material resources among the actors (Wasserman & Faust, 1994), and "resources might include social support, emotional

support, companionship, time, information, expertise, money, business transactions, shared activity" (Williams, 2005, p. 22). For more information about networks, and definitions of some key terms, please read *Introduction to Social Network Research: General Introduction and Major Terminology* (http://www.edis.ifas.ufl.edu/wc195), a separate EDIS publication in this series.

Viewed from a network perspective, every actor in a society is part of an interwoven network of relationships. The network may be envisioned as a fishing net, providing both opportunities for and constraints on the behavior of actors. SNA helps researchers and Extension professionals capture the functioning or interaction of any actor or Extension clientele within the network as a whole (Brass et al., 2004; Kilduff & Tsai, 2003). SNA studies can be conducted at two levels, as one-mode and two-mode. In one-mode studies, both rows and columns in a matrix represent the same single set of actors (See Figure 1), while in two-mode matrix (see Figure 2, the network map drawn from a two-mode matrix of UM Extension and program areas), the rows and columns refer to different set of actors (non-interchangeable) (Borgatti, Everett, & Johnson, 2013). The two-mode matrix can be converted into a one-mode matrix using affiliation procedure in UCINET software (Borgatti et al., 2013).

Wasserman and Faust (1994, p. 4) proposed four theoretical propositions that define SNA:

Participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
A		1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	1	1	1	1	0	1	0
B	1		1	0	1	1	1	0	0	0	1	1	0	0	1	0	0	0	0	1	1	1	0	0	1
C	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	
D	1	0	1		1	1	1	0	1	1	1	1	0	1	1	0	0	1	1	1	0	0	1	0	
E	1	1	1	1		1	1	0	1	1	1	0	0	1	0	0	0	1	1	1	0	1	0		
F	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0		
G	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
H	1	0	1	0	0	1	1		1	1	1	0	1	1	1	1	0	1	0	0	0	0	1	0	0
I	1	0	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	
J	1	0	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	0		
K	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	0		
L	1	1	1	1	1	1	0	1	1	1		0	0	0	0	1	0	0	0	1	1	0	1	0	
M	0	0	1	0	0	1	1	1	1	1	0		1	1	1	1	1	0	0	0	1	1	0		
N	1	0	1	0	1	1	1	1	1	0	1		1	1	1	1	1	0	1	1	1	0			
O	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1		
P	0	0	1	0	0	1	1	1	1	1	1	0	1	1	1		1	1	1	0	1	1	1	0	
Q	0	0	1	0	0	1	1	1	1	1	0	1	1	1		0	1	0	0	0	1	0	0		
R	0	0	1	1	0	1	0	1	1	1	0	1	1	1	1	0		1	0	0	0	1	1	0	
S	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	0	1			
T	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	0	1		1	1	0	1			
U	1	1	0	1	1	1	1	0	1	1	1	0	0	1	0	0	0	1		1	0	1	0		
V	1	1	1	0	1	1	0	1	1	1	1	0	1	1	1	0	0	1	1		0	0	1		
W	0	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0		1	0		
X	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	1	0	1		0	
Y	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	

Figure 1. Matrix for Cienega Watershed Participants Collaborating on Invasive Species Issues in 2008.
Credits: Adapted from "Social network analysis: A tool to improve understanding of collaborative management groups" by A. C., Springer, and J.E. de Steiguer, J. E. (2011), *Journal of Extension, 49*(6), 6RIB7.
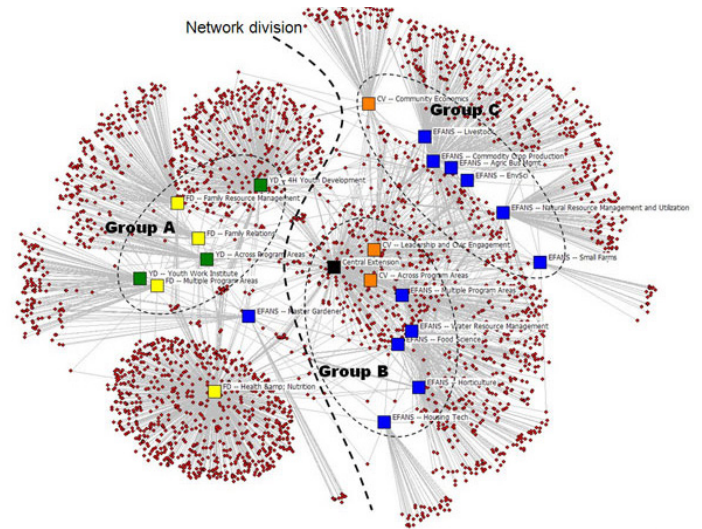

Figure 2. Network map of UM Extension by program area.
Credits: Adapted from "Mapping Extension's networks: Using social network analysis to explore Extension's outreach" by T., Bartholomay, S., M. S., Chazdon, Marczak, and K. C., Walker, 2011, *Journal of Extension, 49*(6), 6FEA9.

• Actors in all social systems are interdependent, not independent;

• Actors are related through links that channel information, affection, and other resources;

• The structure of those relations both constrains and facilitates action; and

• The patterns of relations among actors define economic, political and social structures.

Use of Social Network Analysis

SNA, which combines both method and theory, constrains studying the individual actor in isolation because the actor is part of a network. Therefore a *dyad,* or relationship between two individuals or actors, is the building block of the social network study (Borgatti & Everett, 1997; Williams, 2005). In traditional social sciences the data set includes a person-by-attribute matrix, where the point of study is an individual in isolation and attributes of an individual are the variables. For example, a study might explore how the gender of an individual affects their annual income. In social network studies, the data set is the relationship between two individuals, which forms a person-by-person matrix as a means for capturing data for a single variable (dyadic attribute) among a set of actors (Figure 1) (Borgatti & Everett, 1997).

SNA has been used extensively by disciplines such as sociology, public health, and business management for describing various individual or organizational outcomes (Springer & de Steiguer, 2011). Considering Extension's role in solving problems at the local level, our profession can benefit greatly from a methodology that can be used to understand relationships as well as the flow of information. For example, SNA may be used to study how strongly the decision of an Extension client to adopt a specific lawn management practice is influenced by his or her close and extended family, neighbors, close friends, and other people who were part of the Extension client's network.

SNA can be applied in five major themes: "the structure and functioning of organizations; genealogies of knowledge formation and transmission; the operationalization of social capital concepts; the diffusion of information and innovation; and the regulation of social networks" (Vera & Schupp, 2006, p. 410).

Depending on how data are collected and analyzed, the networks can be approached as *sociocentric* (whole network) and *egocentric* (personal network). In the whole-network approach, connections (ties) among all existing pairs of actors in the network are collected. Once we have data for the whole network, we can extract the subgraph from the whole network representing the connections of an individual actor, which is also called an ego network (Borgatti et al., 2013).

How to Conduct Social Network Analysis

Sociocentric (whole-network) approach

An SNA study can be conducted using six steps. We will use the example of identification of the source of normative messages for residential landscaping practices, such as the application of fertilizers and pesticides to residential lawns:

1. Define the network and the different actors involved in the network. This often is done through needs assessment. In our example, the actors may be the residents and the tie is the common source of information for two people such as a community opinion leader or the county Extension educator.

2. Develop an instrument, often a questionnaire, to collect data about the network, particularly about other actors with whom the participant interacts. Questions in our example include: "Who are your main sources of information for your decision to use fertilizers and pesticides on your lawn?"

3. Collect data from actors. In this case data are collected from residents in the identified network using the questionnaire developed in the Step 2. This step will identify actors (residents) and ties (common source of information for two residents such as a community opinion leader or county Extension educator).

4. Input data to UCINET 6 (a user-friendly SNA package for analysis of social network data) (Borgatti, Everett, & Freeman, 2002). This step will produce a matrix of residents and their sources of information for landscaping decisions and ties between them. See Figure 1 for an example of a matrix. Details about UCINET software are available at https://sites.google.com/site/ucinetsoftware/home.

5. Draw the whole-network map of residents and their sources of landscaping information through Netdraw (Part of UCINET software package) (Borgatti, 2002). For example see Figure 2.

6. Use software (UCINET) analysis to identify the primary sources of normative messages and to defining which sources of normative messages have the greatest effect on an individual's landscape decision-making.

Egocentric (personal network) approach

The egocentric-network analysis approach follows similar steps (1–6) to the sociocentric approach but utilizes two extra steps between Steps 4 and 5 of the sociocentric approach as described above.

The two extra steps are:

- Conversion of the two-mode matrix of residents and their sources of information for landscaping decisions into a one-mode matrix of residents by residents using the affiliation process in UCINET software.

- Once we obtain the network of residents by residents we can use the UCINET software to extract a subgraph representing the network of an individual resident.

Application of Social Network Analysis to Extension

Bartholomay, Chazdon, Marczak, & Walker (2011) used SNA to understand the outreach of Minnesota Extension to organizations which were external to the University of Minnesota (UM). They assumed that networks play an essential role in how and where Extension carries out its outreach activities. They used a survey with questions about who initiated the connection with Extension and the perceived importance of Extension's contribution to the organization.

The network maps of UM Extension revealed that its network was widely distributed but the whole network was divided into two parts (as expressed by the dotted network division line in Figure 2), with youth development and family development programs located on the left side of divide and other programs and central Extension on the right side of the divide (Figure 2). Overall, the authors suggested that SNA has great potential and strongly recommended it be included in Extension evaluation agenda to improve reporting and internal collaboration (Bartholomay et al., 2011).

Kumar Chaudhary (2014) used SNA to understand the diversity and reach of Penn State Extension (PSE) and the influence of network variables and Extension program outcomes from secondary data in the form of program listings and their stakeholders. Results showed that the network of PSE is very widespread and each program was connected to a large number of stakeholders. Kumar Chaudhary concluded that SNA provides a valuable methodology for understanding the reach of Extension in the community, various program outcomes, and ways Extension can collaborate better at various levels to improve the performance of a specific program or the organization as a whole.

Other examples for the application of SNA include:

- Understanding the networks of collaborative watershed initiatives (Springer & de Steiguer, 2011).
- Defining interaction between students and teachers in a student teaching program (Roberts, Murphy, & Edgar, 2010).
- Understanding networking among 4-H youth on social media sites (Rhoades, Thomas, & Davis, 2009).

Applying SNA to Future Extension Research

In general, SNA may be useful in understanding the reach of Extension in communities, evaluating educational programs; identifying the key persons and key connections in the adoption of innovation; understanding collaborative initiatives; and networking among individuals, organizations, or counties.

Conclusion

SNA is an innovative approach for Extension educators to understand various behaviors of their stakeholders such as how innovative ideas spread in the community, who are the major sources of information for natural resources management decisions, whom Extension should contact to get the word out to the larger community, and many others. Extension educators may consider including this method in their evaluation agenda to improve their reporting process, make a stronger case to funders that their program is making a difference, and increase collaboration among different stakeholders based on their common interests.

References

Bartholomay, T., Chazdon, S., Marczak, M. S., & Walker, K. C. (2011). Mapping Extension's networks: Using social network analysis to explore Extension's outreach. *Journal of Extension*, 49(6), 6FEA9.

Borgatti, S. P., (2002). *Netdraw Visualization Software*. Cambridge, MA: Analytic technologies.

Borgatti, S. P., & Everett, M. G. (1997). Network analysis of 2-mode data. *Social Networks, 19*(3), 243-269.

Borgatti, S. P., Everett, M.G. & Freeman, L. C. (2002). *UCINET for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. London: SAGE Publications.

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. (2004). Taking stock of networks and organizations: A multilevel perspective. *Academy of Management Journal*, 47(6), 795-817.

Kilduff, M., & Tsai, W. (2003). *Social Networks and Organizations*. Thousand Oaks, CA: Sage.

Kumar Chaudhary, A. (2014). *Diversity and reach of Penn State Extension programs and effect of brokerage and network position on extension program outcomes through Social Network Analysis (SNA)* (Unpublished master's thesis). The Pennsylvania State University, State College, PA.

Rhoades, E., Thomas, J. R., & Davis, A. (2009). Social networking among youth: How is 4-H represented. *Journal of Extension*, 47(5), 5FEA6.

Roberts, T. G., Murphy, T. H., & Edgar, D. W. (2010). Exploring interaction between student teachers during the student teaching experience. *Journal of Agricultural Education, 51*(1), 113-125.

Scott, J., & Carrington, P. J. (2011). *The Sage Handbook of Social Network Analysis*. London: SAGE Publications.

Springer, A. C., & De Steiguer, J. E. (2011). Social network analysis: A tool to improve understanding of collaborative management groups. *Journal of Extension*, 49(6), 6RIB7.

Vera, E. R., & Schupp, T. (2006). Network analysis in comparative social sciences. *Comparative Education, 42*(3), 405-429.

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and applications*. Cambridge: Cambridge University Press.

Williams, K. H. (2005). *Social networks, social capital, and the use of information and communications technology in socially excluded communities: a study of community groups in Manchester, England* (Unpublished doctoral dissertation). University of Michigan, Ann Arbor, MI.

Zack, M.H. (2000). Researching organizational systems using social network analysis. *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*. doi: 10.1109/HICSS.2000.926933