Agricultural Knowledge and Information Systems: A Network Analysis

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Abstract

Röling and others argue that research and extension should not be seen as separate processes involving distinct institutions which must somehow be linked. Rather, scientists, specialists, extension workers, consultants and producers should be seen as participants in a single agricultural knowledge and information system (AKIS). This perspective on research, extension and adoption as activities that occur within a network offers new insights into the way in which technology transfer occurs, and new ideas as to how to increase the rate of adoption of new ideas and techniques in farming. In this study, we use network management theory and applied network analysis to operationalise the concept of an AKIS and to test the relationships between system characteristics and the effectiveness of technology transfer. The paper is based on the analysis of two networks associated with a large multi-site regional research and extension project in the temperate high rainfall zone of south-eastern Australia. The results indicate that network structure and the performance of individual network members have a significant impact on the ability of an AKIS to facilitate technology transfer.

Keywords: agricultural extension, technology transfer, network analysis.

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1. INTRODUCTION

An agricultural knowledge and information system (AKIS) is a network made up of organisations and people who are linked by commercial, professional or social relationships (Röling 1988). Such a network may consist of producers, researchers, consultants and extension professionals with a common interest in a particular production technology. Röling argues that the effectiveness of technology transfer through an AKIS depends critically on the existence of a system of incentives for network members to communicate with each other and to develop, manage and adapt the network as technology transfer proceeds.

Our aim in this paper is to improve the understanding of how the structure and function in an AKIS affects the incentives for participation in the network and through this, the effectiveness of technology transfer. The research is based on the analysis of the networks associated with a large multi-site extension project conducted by a government and producer funded research and development corporation henceforth referred to as the Program. The Program provided a unique opportunity to assess the relationship between technology transfer and the characteristics of an AKIS while holding relatively constant other factors such as gross organisational structure and the general nature of the innovation. Social network analysis techniques are used to map the networks at two locations and show the differences in their functioning.

2. BACKGROUND

The reasons for which the adoption of new ideas and techniques by producers is often slower than might be desirable have been widely discussed. It has been suggested by some that researchers and others have not invested enough time and energy in developing and marketing their ideas. Researchers have also been accused of concentrating their activities in areas that are not a priority for producers. while others feel that producers on the whole are too traditional and conservative to adopt new ideas. Conversely, many believe that these are really symptoms of a deeper problem which is that producers have not been sufficiently involved in the research and development process. They argue, if producers were more involved in the process of developing research findings into commercially sound ideas and techniques then more research would translate into commercial practice.

The idea that poor commercialisation rates and slow adoption rates in agriculture stem from inadequate consultation with producers has been developed and elaborated in the concept of an agricultural knowledge and information system (Röling 1988 and 1990, Bunting 1986). Röling and others argue that research and extension should not be seen as separate processes involving distinct institutions that must somehow be linked. Rather, scientists, specialists, extension workers, consultants and producers should be seen as participants in a single agricultural knowledge and information system (Röling 1990, 1). An AKIS is a network made up of organisations and people who are linked by commercial, professional or social relationships. Röling and others believe that the nature of the links between the people and the

organisations within this system have a critical impact on the effectiveness of technology transfer (Röling 1988). Ideally, these links are conduits for the dynamic, two-way exchange of information, knowledge and skills between people both within and between organisations.

The effectiveness with which an agricultural knowledge and information system empowers producers to innovate and improve the productivity and sustainability of their enterprises depends on which people and organisations participate in the system (system membership). It also depends on the way these are linked in the system (system structure) and on the nature of the relationships created by these links (relational content). If producers are not members of the system and if links are not established between producers and researchers then research activities will tend to move in directions dictated by the interests of researchers (Röling 1990, 34). If the links between researchers and extension staff do not involve relationships which facilitate the exchange of information between these two groups then the translation of research findings into farming practice will be limited.

Essential to the formation, maintenance and the effectiveness of an agricultural knowledge and information system are the incentives for individuals to create, and maintain, the sorts of relationships necessary for the two-way flow of information and knowledge. The greater the concordance or overlap in interests of researchers, extension agents and producers the stronger the incentives to create relationships that promote the exchange of information and knowledge. Consider, for example, producer groups involved in self-directed learning projects. With this type of project, producers identify the research problem themselves. They also manage and undertake the research, drawing on outside expertise as required. The commitment of participants to the success of the project will be high because they have control over the project and they believe the potential benefits will be substantial. Hence, personal and commercial incentives arise in this type of project to prompt producers to initiate, develop and maintain relationships with researchers, extension agents and other professionals.

In the private sector, commercial imperatives provide a powerful incentive among researchers, distributors and buyers to initiate and maintain social and commercial relationships for the purposes of information exchange and two-way learning. Furthermore, as many of the members of the agricultural knowledge and information system associated with a particular technology may belong to the one organisation, such as an agribusiness company, the organisational setting can be deliberately designed to foster and support the relationships essential to the functioning of the network.

When the public sector is involved in technology transfer the overlap or concordance in the interests of producers, extension agents and researchers may be limited and this may substantially lower the effectiveness of the research and development process (Mandell 1990). There are many reasons why the concordance of interests may be limited (Röling 1990, 34-35). Many of these reasons are products of

differences in the organisational objectives of individual government departments, agencies and public organisations. These differences are reflected in different reward and incentive systems. For example, universities focus on research at the expense of product development and extension. Career advancement within the university system is based on scientific publications and not on the uptake of new ideas by producers. Some reasons for the limited concordance of interests relate to the way organisations are (or are not) linked together. For example, if research finishes at publication while extension starts with recommendations, then a gap occurs in the research and development process. This gap, which will be reflected by the absence of links between research institutions and extension organisations, will slow the rate at which new ideas are developed into commercial practice.

In short, despite the existence of an array of public sector research and extension organisations and producer organisations, the differing goals of these organisations, and the differing incentives faced by individuals within them may impede rather than facilitate technology transfer (see Fennell and Warnecke 1988). By considering the different elements as members of a network some of these difficulties may be overcome. This paper investigates the functioning of two such networks. In the next section, the data are described along with their collection. Section four sets out the results and conclusion are drawn in section five.

3. DATA COLLECTION AND ANALYSIS

There are three basic stages in describing an agricultural knowledge and information system. The first is to identify the individuals and organisations that form the system. Identifying the members of an agricultural knowledge and information system is not a simple task. The task is complicated by the need, for instance, to draw a boundary defining the membership of the system or network in order to keep the study within feasible limits. This means excluding people or organisations that could legitimately be regarded as members of the network. For instance, an extension officer employed by a State Department of Agriculture may be identified as a member of the network at a trial site. The question arises then, is the officer's superior in head office also a member of the network? If so, are others at head office members of the network? If not, why not?

The second stage is to identify the links between the members of the system. The task of identifying links may be complicated by the need to restrict the analysis to only a sample of members in order to keep the analysis manageable. This again is a boundary problem (Knoke and Kuklinski 1982, 22-23). For example, a number of producers may be intimately connected with a trial site. These producers will have their own personal networks of producers, suppliers and so on. Each of these will, in turn, have their network of farming and business contacts. The need for a stopping rule to restrict the range of links under investigation is clear.

The third stage is to characterise the nature of the relationships between members who are linked together (relationship content). A number of issues are involved in the measurement of relational content. These are discussed in detail in the following section.

To gain a preliminary understanding of the membership, structure and relational content of the agricultural knowledge and information system surrounding a trial site, a focus group was held with a representative group of Program staff and with producer committee members involved with one of the Program research sites. The participants at this meeting identified a range of people who were members of the knowledge and information system at that research site. Participants identified individuals as members of the network on the basis that the individuals were active in the operation of the Program at that research site. In other words, these individuals performed certain functions (for example, administrator, researcher, technical staff, and producer). The participants in the focus group identified 14 different groups in the network at their research site (see table 3.1). The participants were able to identify 75 people as being members of the network at this research site[2] and who lived in the immediate area.

The rule used by the focus group participants to identify network members corresponds with one of the strategies presented by Laumann, Marsden and Prensky (1983). They describe eight strategies that may be used for determining the boundaries of networks. The fifth strategy they describe closely resembles that used by the focus group. With this strategy, membership is based on participation or interest in one or more events, activities or concerns (Laumann *et al.,* 1983). In the case of the research problem in question, the members of the network are all those who participate in the Program or show an interest in it. Under this strategy, people whose actions are inconsequential, either because they have no interest in the Program, or the trial site, or because their significance to other members is trivial, are excluded (Knoke and Kuklinski 1982, 23).

Given this definition of membership, the task of identifying links between members is, in principle, straightforward. Starting with a small group of members, the links among the group and the links between the group and others can be traced by creating a record of each person's contacts with other people about the trial site[3] and the Program. Commonly, such records are constructed by asking network members to recall whom they have had contact with regarding the matter of interest. Often, as in this study, recall is the only practical way of obtaining data. However, the accuracy with which people recall actual contact varies (Knoke and Kuklinski 1982, 31-32). Much depends on factors such as the significance of the contact to the person and how frequently contact is made. It is important to bear in mind that the use of recall data may introduce an element of measurement error into the analysis.

[2]The 'research site' is the regional administrative location of the Program

[3]The 'trial site' is the actual experimental site.

The links in the network at a research site were traced as follows. First, people who were *prima facie* positional members of a network at research site because of their function, such as research site researchers, were interviewed and asked to identify people with whom they had contact about the trial site or the Program. These contacts, in turn, were interviewed and asked to identify people with whom they had contact about the trial site or the Program. Given this 'snowball sampling' approach (Knoke and Kuklinski 1982, 23), two stopping rules were formulated to restrict the range of links to a manageable number.

The first rule was to restrict the number of rounds with producers to two, namely the producers who are positional members of the network (first round), and the producers they nominated (second round). This decision was made because, at the time the interviews were conducted, little in the way of results had been generated at most trial sites. This meant that, excepting those who were directly involved in the trial, the trial would be of little interest to most producers. The second rule related to off-site contacts, such as researchers, from other locations. These contacts were interviewed if possible but any contacts they mentioned were not interviewed unless they were directly involved in the Program. The reasoning behind this rule was that the trials would only be of consequence to those people who were directly involved in the Program.

3.1 Subject Matter

Having settled on processes for identifying network members and the links between them, it remains to characterise the nature of the relationships between members who are linked together (relational content). Relational content refers to the nature of the relations between members of a social network and is analogous to the subject matter discussed between people in a network. The subject matter discussed between two people depends on the purpose of the study. For example, in a study of a friendship network, the subject of interest between two members of the network might be whether one member had asked the other for advice on personal matters. In the case of the networks at each research site, the subjects under discussion between network members would relate to different aspects of the Program. We would expect the subjects discussed between two researchers to be different from the subject of a discussion between an extension officer and a producer.

The nature and scope of the subjects discussed was explored using two approaches. The first approach we used drew on the knowledge and experience of the focus group participants as network members to list subjects discussed among members of the network. These were validated using the second approach, which involved interviews with a separate group of research and extension staff from State agriculture departments.

The first approach to defining subject matter worked as follows. Using the list of different types of network members identified in the focus group (table 3.1), the focus group members were asked to identify the likely

subjects discussed between network member pairs where the individuals in a pair are different types of network members (for example, a pair made up of a researcher and a technical officer).

Table 3.1:
Membership of network at focus group trial site.

- Research officers
- Professional officers
- Technical officers
- Post-graduate students
- Researchers, other sites
- Technical officers, other sites
- Researchers, other States, universities, and CSIRO
- Extension officers
- Landcare co-ordinator
- Agricultural consultants
- Fertiliser company representatives
- Seed company representatives
- Producers, local management committee
- Producers, other

Table 3.2:
Subjects discussed between network members.

Subject Number	Subject
1	Program objectives
2	Theoretical background onthe management of the research problem
3	Methodological aspects (experiment establishment, measurement)
4	Practical trial site management and operation
5	Problem identification and solution in project operation
6	Discussion of results
7	Validation of results
8	Developing recommendations
9	Disseminating recommendations
10	Research problem generally

Since it was important to identify all the subjects discussed between network members, the focus group participants identified the likely subjects of discussion for every possible pairing of member types. The list of subjects is reported in table 3.2. Another factor to be considered in characterising the content of links between network members is the context in which links or relationships exist. The context within which relationships between network members occur may have an influence on the outcomes of the Program.

The relationship between members may occur within a social, organisational or collegial context. An organisational context occurs where links are formed between individuals largely because of the responsibilities entailed in positions they hold in their organisations. For example, the link between a researcher and the finance officer of a funding agency is likely to be organisational as it probably derives from the administrative and accountability responsibilities each individual bears. According to the participants at the focus group, most of the relationships in the research site networks tend to be collegial in nature. Collegial relationships exist where both persons bring their professional expertise to the relationship in equal measure and organisational influences like seniority are unimportant.

The set of subjects which the focus group participants identified as forming links between network members was validated using the approach of Burt and Minor (1983). This approach involved conducting exploratory interviews with the research and extension staff of State Agriculture Departments. The interviewee was asked to develop a classification of relational contents associated with the activities involved in the Program. The congruence between the typology obtained from these interviews and the subject areas obtained from the focus group led us to conclude that the relational content of links between network members could be satisfactorily described using the subjects identified at the focus group.

3.2 Interviews

Having formulated a framework for identifying network members, for identifying the links between members and the subjects discussed, a schedule for interviewing members of the networks at the trial sites was developed. The aims of the interview were:

- to identify the people with whom each interviewee has contact regarding the trial site and the Program generally;
- to determine the nature of these contacts in terms of frequency, level of influence, the context in which the contact occurs, subjects covered and the period over which the contact has occurred;
- to determine each interviewee's views on the seriousness of the problem the Program was addressing, the factors causing the problem, methods of overcoming the problem, the advantages and disadvantages of using different management strategies to overcome the problem, and their membership of societies or groups; and
- in the case of the farmers involved, to determine how the research problem investigated under the Program was represented in their production context.

For the purpose of this paper, we are reporting on two of the five research sites where interviews were conducted. These two research sites were selected because similar numbers of interviews were conducted at each. When arranging the interviews, initial telephone contact was made with the researcher responsible for the research site to identify the people with whom they have most contact regarding either the trial site itself or the Program in general. An interview was then arranged with the researcher and the people that they nominated. Interviewees nominated as few as one person and as many as 40 people who they had most contact with. The average number of contacts nominated by the people who were interviewed was ten. When this initial round of face-to-face interviews was completed, over 120 people had been identified as network members.

To restrict the scope of the second round to a manageable number we examined the lists of nominations to find people that had been mentioned twice or more. We assumed that people who were named by two or more interviewees would be more likely than those who had only been nominated once to play a significant role in the network at a research site. Those who had only been nominated once were excluded from the second round of interviews. The remaining people were then contacted by telephone and asked if they would participate in the study and be willing to fill in a schedule if it was mailed them. When the person had received the survey, they were contacted a second time to 'talk them through' the survey schedule and answer any questions. This procedure was also used for any people from the first round that were not available for face-to-face interviews. This process resulted in completed schedules from a total of 28 people across the two research sites.

3.3 Analytical Methods

There are a number of ways of approaching the analysis of the agricultural knowledge and information networks at the Program research sites. In this report, we concentrate on analysing the structure of networks and the subjects discussed between people in each network. In other words, we examine the way in which people are linked together (structure) and the topics they discuss (subject matter)[4].

The way in which people are linked together has a profound affect on the extent to which information is shared. For example, in a decentralised network each person may be in contact with, or linked to, a number of other people. In a centralised network there are one or two people who everyone knows and few people have contact with anyone else, apart from these one or two people. In the decentralised network information can pass from one person to another by a variety of paths. This means that information exchange in the network should not be greatly affected by the changes in membership (caused by the transfer or retirement of personnel for example). In a centralised network, the quality of information

[4] The social network analysis software used to compute network measures was UCINET version IV (Borgatti, Everett and Freeman 1991). Sociograms were produced using KRACKPLOT (Krackhardt, Lundberg and O'Rourke 1993).

exchange will depend greatly on the skills and attitudes of the one or two people who are at the centre of the network. Such a network could be severely weakened by the departure of one of these central figures.

There are a variety of measures of centralisation. Some describe the importance of an individual, others provide a summary measure of centralisation for a network as a whole. We report some common measures of network centrality. When presenting centrality measures we also comment on other aspects of linkages such as the distribution of reciprocal linkages. In the context we are considering, a one way link might occur when one person is influenced by a second person but the second person is not influenced by the first. A reciprocal, or two-way, link occurs where both people influence each other. With regard to information exchange, reciprocal links would seem to be a more effective and efficient means of network communication than one-way links.

We incorporated subject matter discussed into our analysis by calculating the centralisation measures for a number of separate subjects reflecting different aspects of research site operation under the Program (see table 3.2). For example, we calculated separate centrality measures for discussion of results, development of recommendations and dissemination of recommendations. This approach allowed us to identify differences across the research sites in the membership and structure of a network with regard to discussions among members about a particular topic. For example, in relation to the dissemination of results, is the network decentralised at one research site and centralised at another? It also allowed us to identify differences in the way information is exchanged about various topics at a particular research site. For example, to what extent are the people who discuss results also the people who talk about developing recommendations. Finally, this approach allowed these types of differences to be compared across the two research sites.

4. RESULTS

The two research sites discussed in this paper are referred to as Site A and Site B. Cooperation by members of the networks was dependent on an assurance of anonymity. These assurances provided the opportunity for frank responses regarding the member's perception of the Program and of the influence of other network members.

4.1 Contact Networks

Membership of the networks is summarised in Table 4.1, where the number of interviewees and the contacts mentioned are also listed. The ratio of people contacted to those that comprise the network is also displayed. Both research sites are quite similar with regard to these ratios, this indicates that sampling numbers were similar for both when measured against the number of people who comprised the network.

Table 4.1:
Summary of Contact Networks.

Contact network	Numbers in Contact Network	
	Site A	Site B
Interviewees	13	15
Contacts	42	51
Total	**55**	**66**
Contact/interview ratio	3.2	3.4

Table 4.2:
Summary of Contact Network Occupations.

Occupation	Number of Interviewees	
	Site A	Site B
Researcher	2	5
Extension	3	6
Technical	1	2
Producer	5	1
Other	2	1
	Proportion of Network Members with Various Occupations (%)	
Occupation	Site A	Site B
Researcher	27	28
Extension	18	22
Technical	5	17
Producer	30	16
Consultant	4	6
Commercial	11	1
R&D	5	1
Other	-	9

Note: Proportions for network occupation includes occupations of interviewees.

The occupations of those interviewed and of the network members are presented in table 4.2. Generally, network membership will be dictated by the activities of the network and the personnel at each research site who have particular responsibilities with respect to these activities. However, the Program leaders do have some degree of choice in deciding who they will contact about their research site. Consequently, the differences between the research sites in the occupational breakdown of network members reflect the preferences of the Program leaders, subject to institutional and other constraints. At Site A, less technical staff were involved but a larger number of producers, commercial traders and R&D agency people were listed as network members tan at site B.

4.2 Influence Networks

In table 4.3, the numbers interviewed at each research site who reported being influenced by others in the network, and the number of people influencing them, are reported. An influential person was defined as a person who would cause the interviewee to change their opinion, attitude or behaviour regarding a particular subject relevant to the Program.

Table 4.3:
Summary of Influence Networks.

	Numbers in Contact Network	
Contact Network	Site A	Site B
Interviewees	13	15
Contacts	42	51
Total	**55**	**66**
Contact/interview ratio	3.2	3.4
	Numbers in Influence Network	
Influence Network	Site A	Site B
Interviewees	12	13
Influential contacts	36	20
Total	**48**	**33**
Contact/interview ratio	3.0	1.5

As mentioned earlier, interviewees are unlikely to discuss all aspects of the Program with each person they have contact with because many of people in the networks at each research site have specialised occupations or duties. The interviewees were asked to indicate the subjects they discussed more than just occasionally

with each person they nominated as a contact (see table 3.2). We combined this subject information with the information interviewees provided on who influenced them to construct influence networks by subject for each research site. Figures 4.1 and 4.2 show the extent of influential contact between people about these subjects. The figures show, for each research site, the number of people who are influential about a subject as a proportion of the number of people who are influential in toto.

Figure 4.1: Influential contact by subject - Site A.

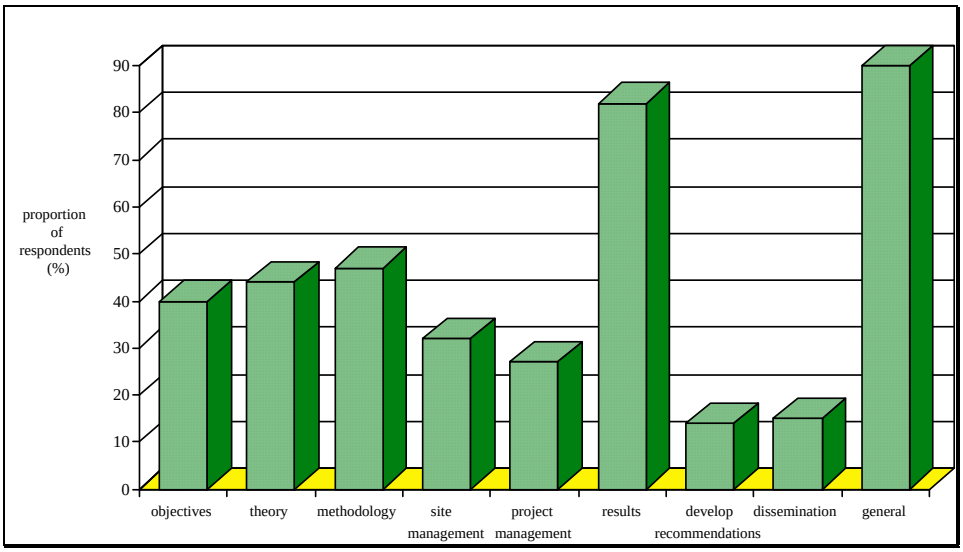
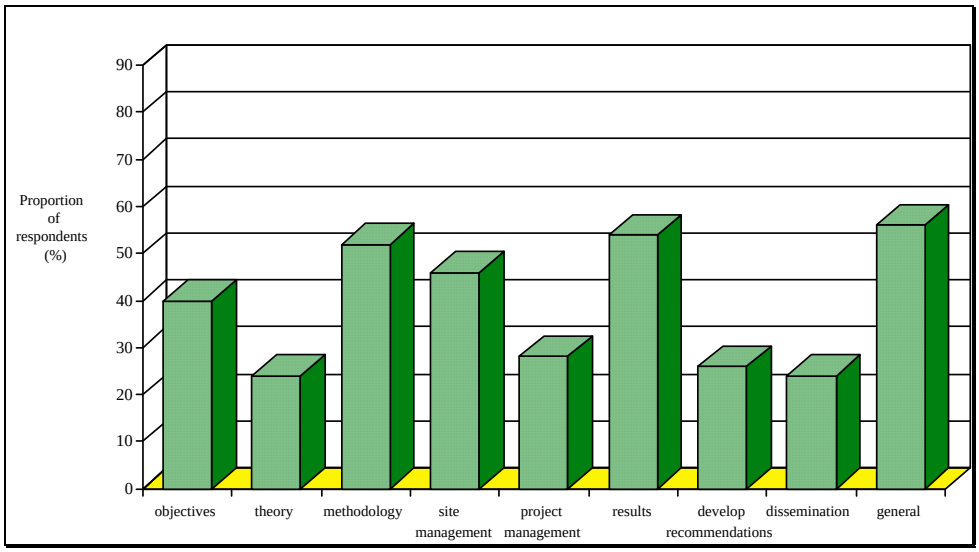


Figure 4.2: Influential contact by subject - Site B.

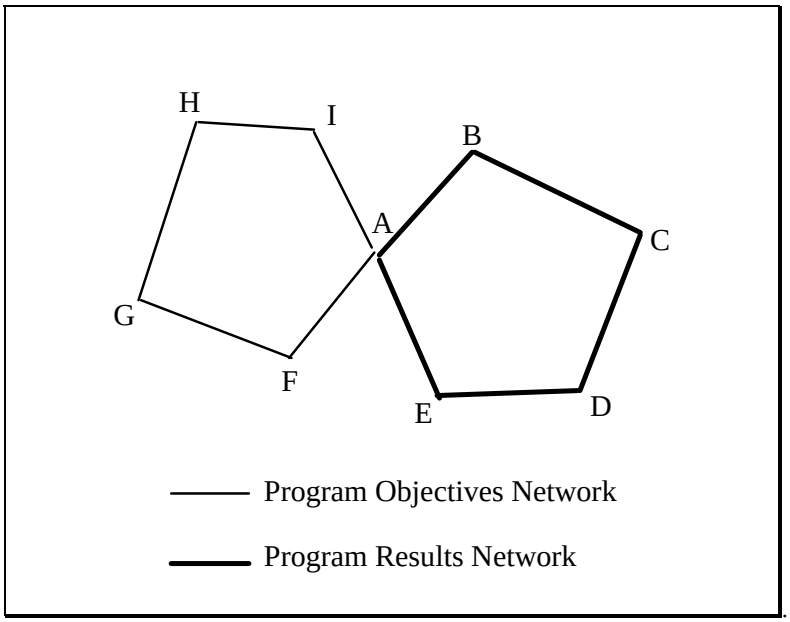


At Site A for example, approximately 70 per cent of people who were regarded as influential by the interviewees at that site have changed interviewees' opinions, attitudes or behaviour with respect to results and the research problem generally. This means that, Site A, a high proportion of influential people have had an influence on both results and the research problem generally.

Notwithstanding this high level of influence and potential activity in these aspects of the Program, most other subject areas are often not influenced by interaction with as many influential people. This appears to be the case at Site B for most subject areas. However, examination of the figures shows that methodology, trial site management, recommendations and dissemination are actually discussed with proportionately less people of influence by network members at Site A than at Site B. If these subjects are judged to more central to the aims of the Program, then Site B might be judged to be more effective overall.

Differences in the range of subjects over which the people at each research Site Are influential have implications for the overlap in subject networks at research sites. The term overlap refers to the situation where one or two members of say the Program Results Network are also members of the Project Objectives Network (see figure 4.3). In this diagram, person A is in the unique situation of being involved in both networks. Should someone in the objectives network need to know what results are being generated, the only person they know who can inform them is person A. The reverse is true for people in the results network. Clearly the interpretation of objectives and results given by person A will be critical to the accurate representation of those situations.

Figure 4.3 - Network Overlap.



At a research site where the influence of most members is restricted to only a couple of subjects the subject networks will be largely dissimilar. Different groups of people will appear in each subject network. It is possible that where there is a high degree of overlap between subject networks at a research site, there is a greater chance that the people at that site will have a shared understanding of the nature of the Program and the projects at the research site.

We investigated the overlap in subject networks in more detail by focusing on the subject networks associated with setting objectives, discussing results and discussing the research problem generally. We chose to focus on these subject networks for the following reasons. First, we needed to limit the analysis to a size that was practical. And second, we believed that in an ideal network, researchers, extension staff and producers should discuss these three subjects. Other subjects, such as theory, experimental methodology or trial site management are more likely to be relevant to particular groups in a network.

The differences in the overlaps at each research site between the subject networks for objectives, results and the research problem generally are presented in table 4.5. The results presented at the top of the table provide a measure of the overlap between the network of people who are influential in terms of program objectives and the network of people who are influential with respect to discussions about results. In the first row of the table, the number of contacts, at each research site, which were influential in terms of program objectives but were not influential in terms of results are reported (as a proportion of contacts which were influential with respect to objectives, results or both). In the second row of the table the proportion of contacts, at each research site, which were influential in terms of results but were not influential in terms of objectives are reported. Finally, in the third row of the table the proportion of contacts, at each research site, which were influential in terms of both objectives and results are reported. The proportions reported indicate that, at Site A, 35 per cent of people who are influential with regard to setting objectives are also influential when it comes to discussing results.

In contrast, at Site B, only very small proportions of influential contacts between people relate to both of these subjects (12 per cent). At this research site most people who are influential in discussing results are not influential when it comes to setting objectives. This suggests that, at Site B, there is much less overlap in the objectives and results networks. In other words, the group of people at this research site who discuss objectives tend to be different from the group of people who discuss results.

In the middle of table 4.5, the overlap at each research site in the networks associated with discussion of program objectives and discussion of the research problem generally is described. The results indicate that at both research sites, people discussing program objectives are also looking at the problem generally 30 to 40 per cent of the time. Discussion regarding results occurs almost 90 per cent of the time among people discussing the research problem at Site A compared to almost 49 per cent of the time at Site B.

Table 4.5:
Two-way overlap in selected subject networks. Values are percentages of influential contacts between people at each research site concerning discussion of the nominated subjects. See text for a more detailed explanation.

Subject network	(%) Site A	(%) Site B
Objectives only	10	36
Results only	55	52
Objectives and results	35	12
Objectives only	3	24
Research Problem only	56	46
Objectives and research problem	41	30
Research problem only	11	27
Results only	3	24
Results and research problem	86	49

Generally speaking, the results reported in table 4.5 indicate that, for the subjects considered, the overlap in the influence networks at the two research sites is greater at Site A than at Site B.

4.3 Network Structure

In figures 4.4 and 4.5, the influence networks at the two research sites for discussing objectives are depicted. The influence networks at each site for discussion of results and for the research problem generally are presented in figure 4.6 through to figure 4.9. In these figures, the members of each network have been assigned a label designating their research site and occupation. For instance, a label such as A.RES.33, which appears in figure 4.4, indicates a researcher at Site A. The number 33 designates the position of the researcher in our database (see Appendix A). Note that network members who are from other research sites not considered in this paper have name labels beginning with the C (for example C.RES.31 in figure 4.4). The arrows in the figures indicate influence. The arrow heads point in the direction of the person who is influential. For example, in figure 4.4 the researcher A.RES.33 is influenced by a number of other network members such as project technician A.TA.40, district agronomists A.DA.23 and A.DA.25 and local producer

A.FARM.75. Examination of figure 4.4 shows that in relation to objectives, A.RES.33 has identified all those in the lower portion of the diagram as being influential.

Figure 4.4: Influence network at Site A for discussion of objectives.
(Codes are described in Appendix A).

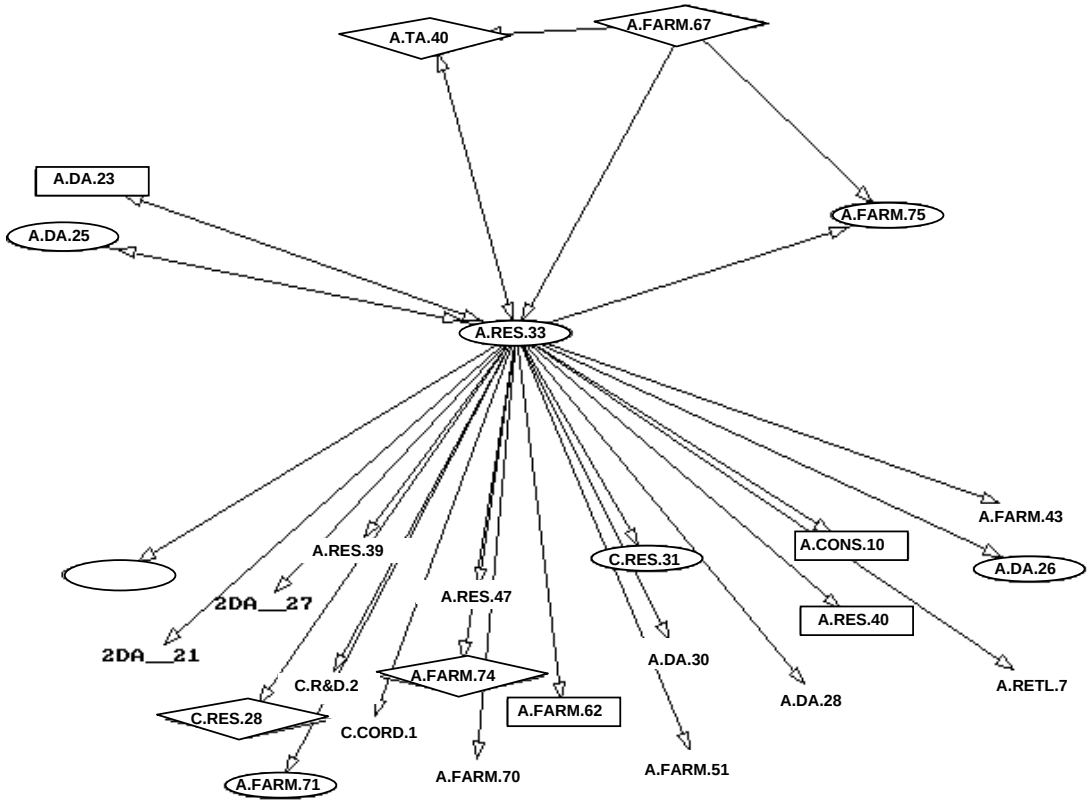


Figure 4.5: Influence network at Site B for discussion of objectives.
(Codes are described in Appendix A).

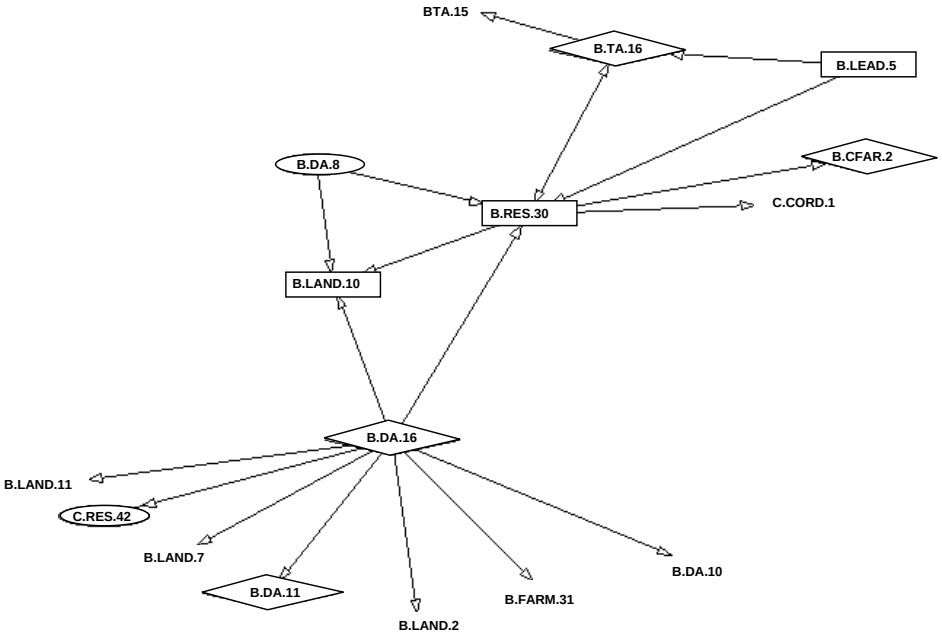


Figure 4.6: Influence network at Site A for discussion of results.
(Codes are described in Appendix A).

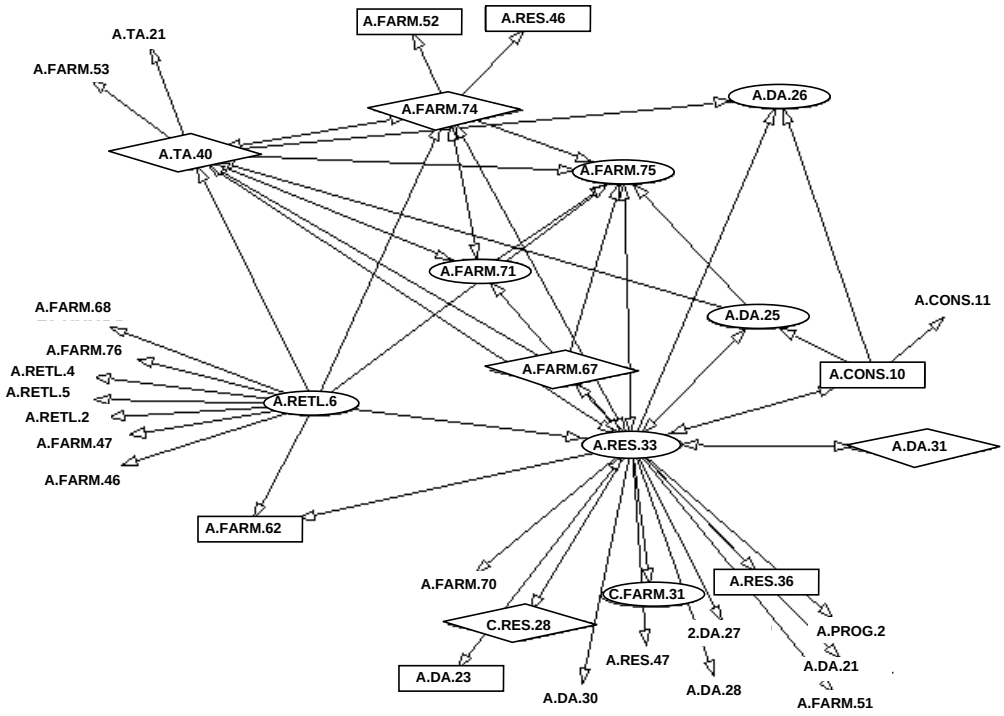


Figure 4.7: Influence network at Site B for discussion of results.
(Codes are described in Appendix A).

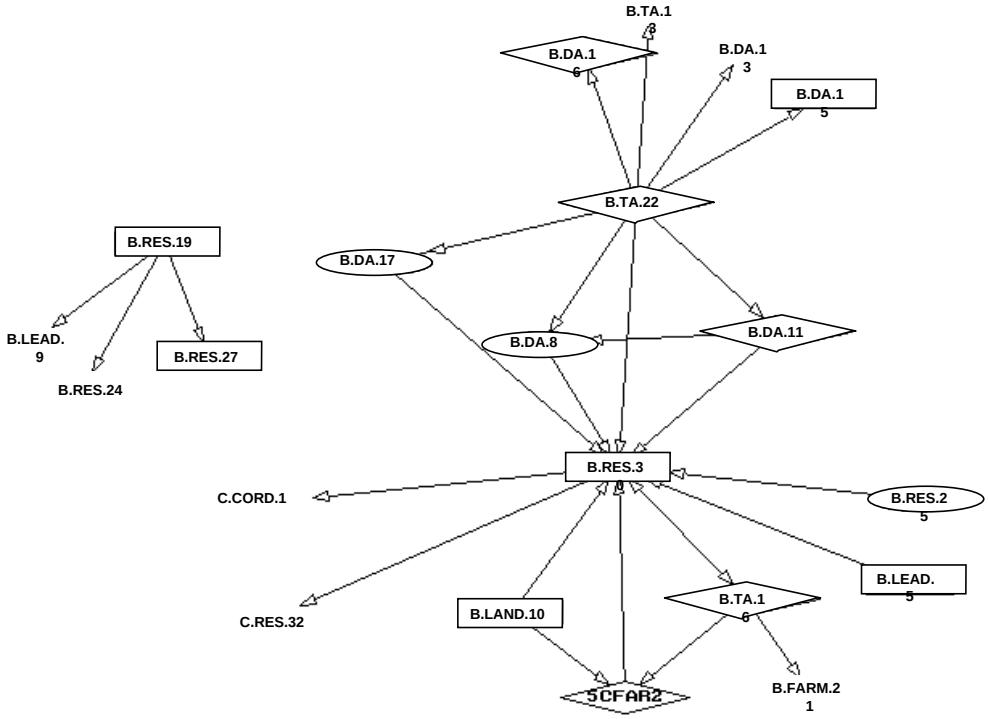


Figure 4.8: Influence network at Site A for discussion of the research problem.
(Codes are described in Appendix A).

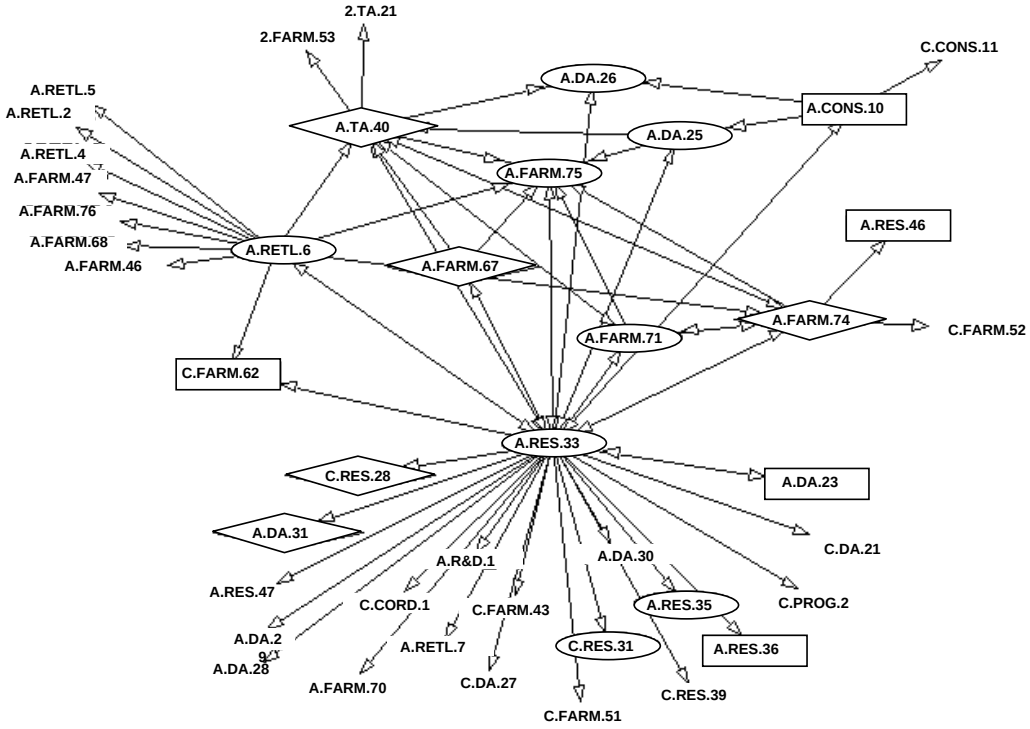
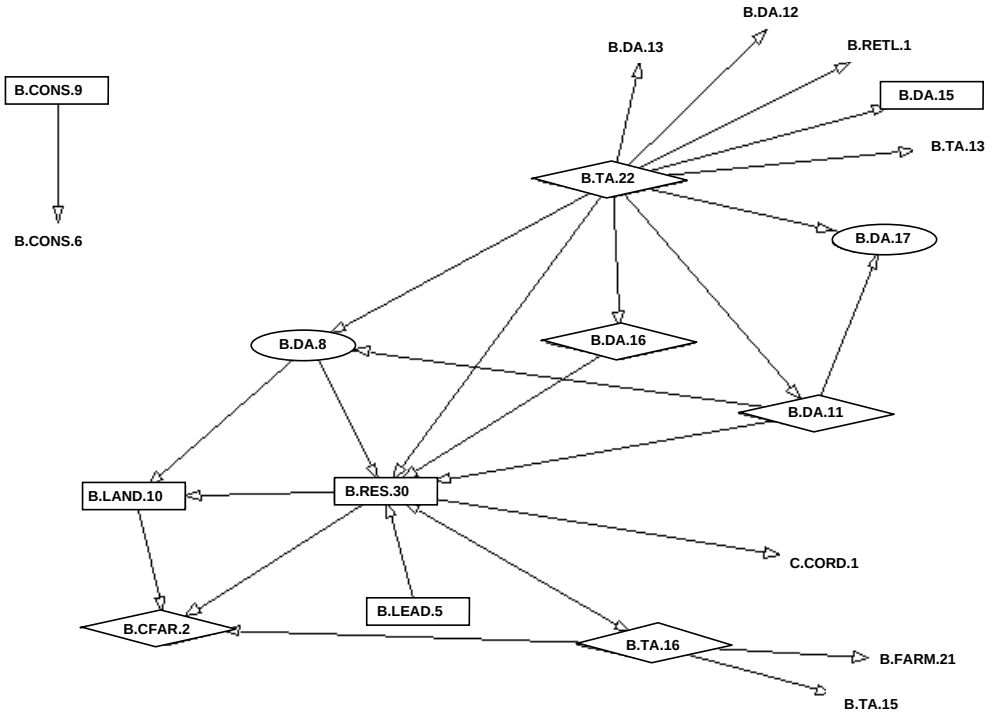


Figure 4.9: Influence network at Site B for discussion of the research problem.
(Codes are described in Appendix A).



Similarly, A.RES.33 influences A.DA.25, A.DA.23, A.TA.40 and A.FARM.67. Hence, lines between members that have an arrow head at one end only designate one-way influence relationships. Where an arrow head appears at both ends of a line between two members, such as between A.RES.33 and A.DA.25, A.DA.23 and A.TA.40, both members influence each other. Therefore, lines that have arrow heads at both ends designate two-way influence relationships.

To gain an understanding of network members' opinions about the Program, respondents were asked to answer five questions designed to gauge their degree of satisfaction with:

- the results of the trial;
- the amount of increase in technical understanding about the research problem;
- how well the results can be applied by farmers;
- how successful the results will be in addressing the research problem; and
- what aspects of the results are new.

The answers to these questions were analysed to give an overall opinion about the Program that is indicated in each figure by the shape surrounding their name label. A Diamond shape indicates that the member generally holds a favourable opinion of the Program at that research site. An ellipse indicates a neutral view and while a rectangle signifies a generally unfavourable opinion. The absence of a shape indicates that the member's opinion of the Program is unknown. This occurs where members were not interviewed. It is noteworthy that A.RES.33 and B.RES.30 (research site leaders) hold neutral and negative attitudes toward the Program respectively.

A detailed examination of interview records revealed that interviewees at both research sites hold favourable opinions about the chances that the recommendations, released under the Program, will be successful in assisting with a solution to the research problem in most situations. They tend to be neutral with regard to the Program generally and whether the practices recommended under the Program are likely to be readily adopted by farmers. They tend to be pessimistic with respect to the possibility that the trials will improve the technical understanding of research problem.

Statistical measures summarising the structure of the networks presented in figures 4.4 to 4.9 are reported in table 4.6 Three measures of network centralisation are reported in the table — 'indegree', 'outdegree' and 'betweenness'. These measures provide an indication of the extent to which each of the objectives, results and research problem networks are dominated by only a few of their members. They are scaled to range from a minimum of zero to a maximum of 100 (Wasserman and Faust 1994, 177).

Table 4.6:
Statistical summary of objectives, results and research problem subject networks.

Objectives Network	(%) Site A	(%) Site B
Network centralisation (in)	11.8	21.4
Network centralisation (out)	99.1	59.5
Network centralisation (between)	14.6	6.5
Network density	7.9	14.1
One-way links	81.3	90.9
Results Network	Site A	Site B
Network centralisation (in)	24.9	42.9
Network centralisation (out)	61.2	37.4
Network centralisation (between)	17.6	10.3
Network density	10.8	9.3
One-way links	70.0	94.1
Research Problem Network	Site A	Site B
Network centralisation (in)	15.9	27.2
Network centralisation (out)	70.8	50.6
Network centralisation (between)	17.9	8.4
Network density	9.3	11.8
One-way links	68.7	95.0

The 'indegree' measure describes the extent to which one or two members are dominating a network by influencing others. A low value indicates that the network is decentralised (Wasserman and Faust 1994, 177-180). This means that people in a network are relatively equal in their influence, each person is influencing a similar number of others. A high value indicates the network is centralised. This means that one or two individuals dominate the network, that is, the same one or two people are influencing most people in the network. On this measure, Site B is more centralised than the networks for Site A. This means that, relatively speaking, influence over others is concentrated among fewer members at Site B than it is at Site A. Interestingly, the results network displays higher levels of centralisation for each research site

suggesting that influence over results is coming from fewer sources in this network than objectives or the research problem generally.

In relation to the diagrams of the networks, a relatively high proportion of the arrow heads in a diagram of a centralised network for this measure will point towards one or two people in the network . This can be observed by examining figure 4.7. The arrow heads in the figure point in the direction of the person who is influential. Note that in this diagram only B.RES.30 has more than two arrow heads directed toward them. In comparison to Site B, the results network at Site A (figure 4.6) is larger and seven members have multiple arrow heads hence this network is more decentralised.

The second measure of centralisation, the 'outdegree' measure, reflects the extent to which a number of members of a network are being influenced by others in the network. A high value indicates that most people in the network are only influencing the same one or two people. A low value means that each member of the network tends to influence different people. On this measure, all networks at Site A are more centralised than those at Site B. This means that, relatively speaking, each member of the network at Site B tends to be influenced by different people. At Site A on the other hand, most people are influencing the same one or two members of the network (see for example figure 4.4). A relatively high proportion of the arrow heads in a diagram of a centralised network for this measure will point away from one or two people in the network and towards everyone else .

The third centrality measure, 'betweenness', describes the extent to which the links between everyone in a network depend on the interaction of only a few members of the network. A high value indicates that the influence that most members of a network exert over each other is channelled through only one or two people in the network. Site A is again more highly centralised on this measure than Site B. This means that, relatively speaking, more members of the network at Site A must influence one person at the centre of the network in order to influence other members of the network.

An examination of figure 4.8 shows that everyone in the upper portion of the figure must influence A.RES.33 in order to influence someone in the bottom of the figure. A.RES.33 performs a 'gate keeping' role, much of the information exchange in the network can only occur if the gate keeper A.RES.33 is involved. The exchange of information through the network at Site A will depend on the capacity of A.RES.33 to accurately interpret and transmit information. The performance of this network will be sensitive to the skills of A.RES.33. As highlighted earlier this network would be weakened by the departure of A.RES.33.

Network density measures the number of interactions between people in a network people as a percentage of the maximum possible number of interactions (Wasserman and Faust 1994, 181). The higher the percentage the denser the network, the more the people in the network are interacting with each other. With

respect to the objectives of the Program, the network at Site B is denser than the network at Site A. The network at Site A is the less dense, despite being the larger of the networks. So although there are more people in the objectives network at Site A, the members of the network at Site A tend, on average, not to interact with more people than the members of the network at Site B.

Finally, the last measure in each section of table 3.9 indicates the proportion of interactions between network members that are one-way. A one-way interaction occurs when one member influences another in a network but the reverse is not the case. A two-way relationship occurs when both members influence each other. Both research sites demonstrate a high proportion of one-way links.

Ideally, the networks at each research site should exhibit low values for all the centrality measures. This would indicate that many members of a network are interacting directly with a high proportion of other members in their network. The value for density should be, correspondingly, high while the proportion of one-way interactions should be small.

To summarise, the network measures used here to examine the influence networks for program objectives, program results and discussion of the research problem have identified some fundamental differences between the workings of the two networks in question. The magnitude of the differences in this example are not large, but the ability to detect structural components of a network provides the opportunity for those responsible for its success, to adjust aspects of network performance, over time, through informed means. Gross measures of the network density are used to describe the level of communication between members. Whether this influential communication is reciprocated between network contacts is described as a one-way link. This measure highlights when information from person A is regarded is as influential by person B, but person A does not include person B as an influential network member.

In this study, Site A is a network that, compared to Site B, has more people in the network who are influential. This influence however, is directed toward fewer people in the network creating the situation where one or two central 'gatekeepers' have the responsibility for interpreting and passing on information. This structural weakness presents the opportunity for the performance of the central person to affect the whole network. By comparison, the structure at Site B is less susceptible to this problem. With this understanding of the networks' functioning, a comparison of farmers perceptions of the Program is provided in the next section.

4.4 Network Performance

In table 4.7, the results of a survey of producers who have visited the trial sites are summarised. The differences in the proportion of producers surrounding each research site who were aware of the project, intended to make use of the results and seek further information is displayed.

Table 4.7:
Summary of producer perceptions.

Producers	Site A	Site B
Number surveyed	33	34
Proportion aware of trial (%)	61	68
	Proportion making Use of Results (%)	
Make use of results*	Site A	Site B
Yes	39	64
No	0	5
Don't know	61	32
	Proportion seeking Further Information (%)	
Seek further information*	Site A	Site B
Yes	60	87
No	5	0
Don't know	35	13

*Results are calculated as percentages of producers aware of trial.

These results should be treated with caution for a number of reasons. First, because changes in perceptions and management of the research problem would be difficult to detect in a random sample of farmers taken early in the life of the Program, only farmers who had visited the trial site were surveyed. Hence, the numbers surveyed depend in part on the extension activities at each research site. Second, names and addresses of visitors to the trial Site Are not recorded. Possible visitors to these trial sites were identified on the basis of the recall of research site staff. Much depends then on the ability of staff to remember visitor details. Third, when we contacted the producer groups we regularly found that a number of members of the groups had not participated in the group visit and therefore were unaware of the trial. Given these qualifications, it appears that awareness of the trials amongst producers who have visited trial sites is marginally higher at Site B than at Site A. These differences may be the result of differences in the level of extension activity at each research site. However, they may also result from measurement problems of the kind we have described.

Producers' responses to the trials appear to be relatively more favourable at Site B than at Site A. Also, a relatively high proportion of producers visiting Site B plan to seek further information about the trial and expect to make use of the results of the trial. In contrast, relatively high proportions of producers who have

visited research Site A are unsure whether they will use the results of the trial. The differences between sites B and A are statistically significant, at least in terms of seeking further information (χ^2=2.7, p=0.10 for use of results and χ^2=4.1, p=0.04 for seeking further information).

There are a number of possible reasons for the differences in producers' perceptions of sites A and B. For example, in discussions with network members at Site A, we discovered that many members at this research site believed that the methods used in the trials may not generate information of practical value to producers in the region around the trial site. We compared the perceptions of producers at both research sites with respect to the severity of the research problem, its causes and the practices they believed are important in managing this problem. We found no significant differences between the research sites with respect to these variables.

In our view, these results indicate that the network at Site B may have been more successful than the network at Site A in particular, at raising awareness of the trials among producers. However, the less favourable perceptions of producers at Site A may well be due to differences in the relevance of the trial protocols to producers in that region, and differences in communication styles used by the Program leaders and their staff at the two research sites.

5. CONCLUSIONS

In this study, we used network management theory and applied network analysis to operationalise the concept of an AKIS in two networks associated with a large multi-site regional research and extension project. We sought to test the relationships between system characteristics and the effectiveness of technology transfer. The study used a combination of focus groups and personal interviews to build a comprehensive body of qualitative data relating to the perceptions of participants while compiling a substantial amount of quantitative data for interpretation using network analysis. These investigations showed that there are some fundamental differences between the two networks examined here, in terms of, the occupations of those involved, subject areas discussed between network members, overlap between people in the various subject networks, network structure and network performance.

Four conclusions are drawn from this study. First, at Site A, A.RES.33 performs a 'gate keeping' role. Much of the information exchange in this network can only occur if the gate keeper is involved. The exchange of information through the network at Site A will depend on the capacity of A.RES.33 to accurately interpret and transmit information. Knowledge of this situation suggests that the network at site A would benefit in the long term from intervention to increase the number of information pathways between network members. This strategy would also lessen the potential damage to the network should A.RES.33 leave the network. Second, the proportion of farmer members in the influence networks at Site B is much lower than at site A. This raises the potential for research to move in the direction of the interests of researchers (and

possibly away from farmers' objectives). By understanding this aspect of network composition, steps could be taken to increase farmer involvement at the influence level. Third, the lack of two way, or reciprocal communication in both networks is disturbing. Information exchange needs to be reciprocated if the system under investigation is dynamic in nature. The low amount of feedback demonstrated at both sites needs to be addressed. Communication workshops for network members would be one method of enhancing this aspect of network performance.

Finally the results highlight that often networks that were set up to perform the same function will vary widely in their structure and performance. Consequently there may be a need for objective measures that can identify those aspects of network that are in need of adjustment. This example has shown that while some common problems can occur, many potential problems are individual, requiring individual responses to improve network performance. Hence, this study has shown that there are substantial differences in the structure of the networks at the two research sites studied. The use of network analysis in the AKIS framework provided a useful methodology for quantitatively studying the networks individually and drawing comparisons between them. The ability to measure network components offers new opportunities to improve the effectiveness of network operation.

REFERENCES

Bunting, A.H. (1986): 'Extension and technical change in agriculture'. *Investing in Rural Extension: Strategies and Goals*. Jones, G.E. (ed). London, Elsevier.

Burt, R.S. & Minor, M.K. (eds) (1983): *Applied Network Analysis.* Sage Publications, Beverly Hills, 352pp.

Chamala, S., Keith, K.J. & Quinn, P. (1983): 'Australian farmers' attitudes towards, information exposure to, and use of commercial and soil conservation practices'. *Tillage Systems and Social Science,* 3(1): 1-3.

Cook, C.W. (1981): 'E. Guidelines for Managing Motivation' in Herbert, T.T. (ed). *Organizational Behaviour: Readings and Cases, 2nd Edition*. Macmillan Publishing Co., Inc., New York.

Daugherty, S.R., Salloway, J.C. & Nuzzarello, L. (1988): 'A Questionnaire for the Measurement of Social Networks and Social Support'. *Connections*, 11(2):20-25.

Fennell, Mary, L. & Warnecke, R.B. (1988): *The Diffusion of Medical Innovations: An applied network analysis.* Plenum Press, New York and London.

Hersey, P. & Blanchard, K.H. (1993): *Management of Organizational Behaviour: Utilizing Human Resources, Sixth Edition.* Prentice Hall, Englewood Cliffs. 536pp.

Johnson, D.W. & Johnson, F.P. (1991): *Joining Together: Group Theory and Group Skills, 4th Edition.* Allyn & Bacon, Needham Heights. 530pp.

Knoke, D. & Kuklinski, J.H. (1982): *Network Analysis*. Sage University Paper No. 28. 96pp.

Laumann, E.O., Marsden, P.V. & Prensky, D. (1983): 'The Boundary Specification Problem in Network Analysis' in Burt, R.S. & Minor, M.J. (1983) *Applied Network Analysis – A Methodological Introduction.* Sage Publications, Beverly Hills.

Mandell, M.P. (1990): 'Network Management: Strategic Behaviour in the Public Sector' in Gage, R.W. & Mandell, M.P. (eds). 1990. *Strategies for Managing Intergovernmental Policies and Networks*. Praeger. N.Y.

Martin, P. (1991): 'Environmental care in agricultural catchments: Toward the communicative catchment'. *Environmental Management,* 15(6):773-783.

Mitchell, R.R., Dowling, P.J., Kabanoff, B.V. & Larson, J.R. Jnr. (1988): *People in Organizations: An Introduction to Organizational Behaviour in Australia.* McGraw-Hill Book Company, Sydney. 565pp.

Röling, N. (1988): *Extension Science.* Cambridge University Press, Cambridge. 233pp.

Röling, N. (1990): 'The Agricultural Research-Technology Transfer Interface: A Knowledge Systems Perspective' in Kaimowitz, D. (ed.) 1990. *Making the Link-Agricultural Research and Technology Transfer in Developing Countries.* Westview Press, London.

Wasserman, S. & Faust, K. (1994): *Social Network Analysis: Methods and Applications.* Cambridge University Press, Cambridge. 825pp.

APPENDIX A

Occupation Codes

Occupation	Occupation Code
Farmer	FARM
District Agronomist/ Ext.	DA
Researcher	RES
Program Administration	PROG
Cooperator Farmer	CFAR
Technical Assistant	TA
Project leader/ Chief Scientist/ Director	LEAD
Coordinator	CORD
Livestock Officer/ Ext.	EXT
TAFE Lecturer	TAFE
Landcare Co-ordinator	LAND
Consultant	CONS
Wholesaler/Retailer	RETL
R&D People	R&D
Sheep/Wool Officer	EXTS
Beef/Cattle/Livestock Officer	EXTC

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