Institute for Sustainable Futures

Social network analysis: a primer on engaging communities on climate adaptation in New South Wales, Australia

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Contents

Summary

A network is a group or system of interconnected people or things. Social networks connect people. Those connections provide advantages to members of the network through access to private information, diverse skills and power, which makes the understanding of networks important for the formulation and communication of policy.

The Adaptive Communities Node used a network analysis methodology to understand the formal and informal knowledge channels that communicate climate change adaptation policy throughout regional communities (Harman et al, 2016; Harman et al 2015a; Harman et al 2015b). The results of case studies in these communities (centred on Shoalhaven, Bega and Orange) have been published through the UTS:ISF NSW Adaptation Research Hub (https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/climate-change/nsw). This primer serves as a companion document to those reports. Using the findings from the regional case studies, its aims are to:

- briefly explain the Social Network Analysis method and some of the metrics used to understand network properties; and,
- suggest future applications for Social Network Analysis by government to communicate climate change adaptation policy most effectively and efficiently.

1. Networks and social network analysis

1.1 Networks

Networks are groups of things and the connections that tie them together. There are many kinds of networks from mobile phones connected by wireless signals and towers, to towns connected by roads, and household appliances connected by the internet. Much of our essential infrastructure, including water, electricity and transport systems is networked. That is, individual parts share information about their condition and operational status to improve the function of the whole system. Network analysis has been used to understand relationships in a wide variety of situations beyond infrastructure, such as flavour clusters in food (Figure 1) and disciplines within human knowledge (Figure 2).

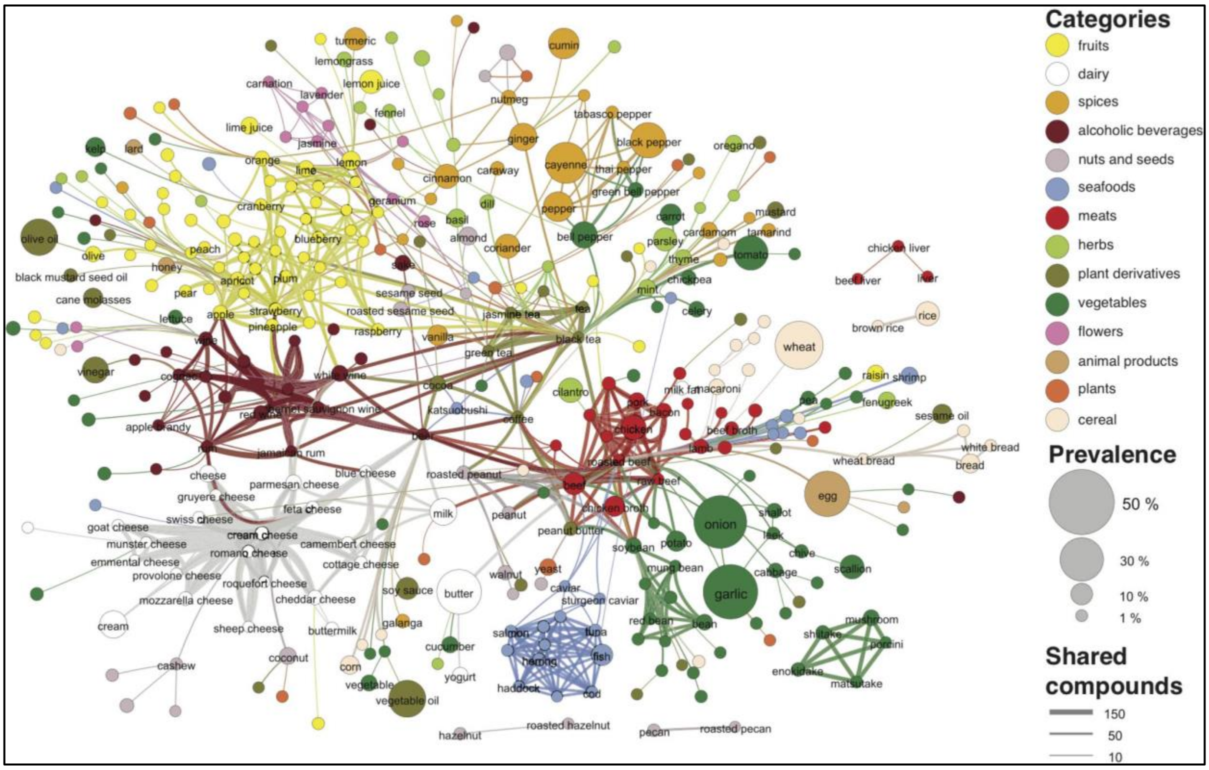

Figure 1: A network showing how 'flavours cluster' by extracting common groupings of ingredients in recipes (Source: Ahn et al 2011)

1.2 Social Networks

Social networks connect people rather than things.
Social networks deliver three key advantages to their members:

- **Private information**, which is gathered from personal contacts who can offer unique information not available to people outside the network. The value of this private information depends on the level of trust placed in the network.
- **Access to diverse skill sets**. The skill set required by a modern organisation is increasingly inter-and transdisciplinary (Fam et al 2017). Individuals with access to a network can overcome their personal skill limitations by developing ties that allow them to trade information, skills and experience with others in the network.
- **Power** in modern organisations is embedded in network information brokers (Cvitanovic et al 2016), rather than through traditional organisational hierarchies. These brokers provide connections between trusted information sources.

Three main types of social networks have been identified (Uzzi & Dunlap 2005):

i. **Operational networks**: include the formal relationships among people in an organisation that allow it to function, such as those established through lines of reporting, superiors, people with the power to block or support a project, and key outsiders such as suppliers, distributors and customers.

ii. **Personal networks**: sometimes called ‘ego networks’ are the connections people develop, both formally and informally, that help them function in society and include friends, family, mentors, referees, and work contacts (e.g. Goggin et al 2015).

iii. **Strategic networks**: provide a strategic advantage by allowing members to look to the future. They are formed from the weak ties to network outliers that can help cope with future disruption to the functioning of an organisation or might be developed for an individual’s career progression.

Operational and personal networks largely form naturally; strategic networks generally need to be constructed through targeted contact.

Social networks can also be classified as formal or informal. Generally, information about climate change from government is shared and adaptation decisions are taken through formal governance networks, that is, the routine interactions among government agencies and through traditional communication channels. However, informal or ‘shadow networks’, often described as the information ‘grapevine’, are also recognised to substantially influence the ways by which individuals and groups share information and engage with the process of adaptation (Pelling, 2010).

1.3 Social Network Analysis (SNA)

SNA allows for the quantitative analysis of the interplay between various entities or nodes within a given network. It is possible to explore similarities (e.g., membership), social relations (e.g., kinship, colleagues), interactions (e.g., attended conference with) and flows (e.g., knowledge dissemination). Terminology may differ between disciplines; however the principles and algorithms utilized for analysis remain the same.

SNA is particularly useful when exploring knowledge dissemination. The efficiency and efficacy of knowledge networks can be measured, and findings can provide useful explanations of, for example, how to enhance operations of emergency services or improve the uptake of policy information (Cunningham et al. 2015; Cunningham et al. 2014).

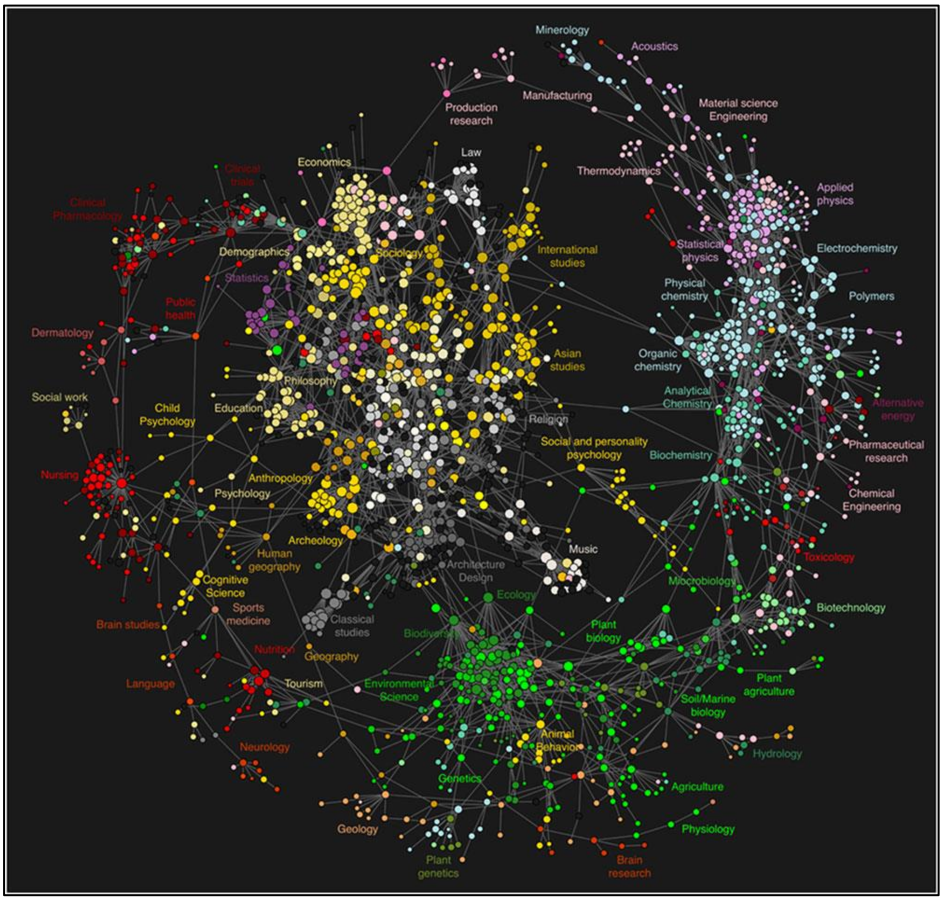

Figure 2: A human knowledge network visualised using social network analysis (Source: Bollen et al., 2009)

2 Types of networks

Explorations of knowledge and dissemination networks have been used in agriculture, bio technology, climate adaptation and energy technology. The attributes of social networks appear to evolve to match their function because different types of network are associated with specific tasks. For example, the internet tends to follow ‘scale free’ laws; this means that it is an extensive network made up of well-connected hubs linked to many smaller nodes. A search engine such as Google, for instance, is a URL (a hub) that in turn connects users to a large number of other URLs (nodes). Transport networks may be organised in a similar way with larger more used stations (hubs), such as Sydney’s Central station, providing links to smaller, less-busy stations (nodes).

In contrast, Australian research demonstrated that transformational adaptation among farmers was more likely to occur when they were members of both small, dense, social-support networks and large, wide-spread, information networks (Dowd et al., 2014).

In addition, a study undertaken by the NSW Government demonstrated that a combination of intra-organizational (within) and inter-organizational (external) connections was the most beneficial for the business of science and policy research and development (Goggin et al 2015).

3 Using SNA in a policy context

Social network analysis can be used to show the channels through which information about a particular policy issue, such as climate change adaptation, is shared. Knowledge of these channels can be useful for policy makers and community engagement specialists to understand how policy messages may or may not be transmitted and received.

Combining the analytical power of quantitative network analysis with qualitative social science techniques, such as semi-structured interviews with network members, enhances the value of the information generated within a policy context, and is particularly useful for a deeper under understanding of information exchange among community members. Through interviews, network members provide additional information on issues related to information flow that cannot be revealed through quantitative SNA alone.

In a series of related studies researchers from the NSW Adaptation Research Hub (Cunningham et al 2016, Harman et al 2015a b) demonstrated the value of combining qualitative and quantitative techniques in SNA for climate adaptation policy. Case studies were conducted in three NSW regions (Shoalhaven, Bega and Orange) and each study revealed a unique place-based story of adaptation through analysis of their social networks. Through these individual studies the researchers sought a 'typology' of effective knowledge diffusion – that is, they were trying to uncover the most effective communication channels for each region and explore the similarities among these communities.

3.1 How is social network analysis done?

Each case study used a common approach involving a 'snowball' sampling procedure to identify members of the local adaptation knowledge network. During interviews, participants were asked where they sought information about climate adaptation and where they shared this information. These responses provided the data to create two networks: an 'access' and a 'share' knowledge network. The researchers analysed the information generated from this process to develop network metrics, and the share and access networks were visualized (see Figures 3 and 4). These two network types are often distinctive in appearance and operate differently in practice. We will use the visualisations of the networks from the Orange case study to illustrate network metrics. The methodology is described in further detail in the sections below

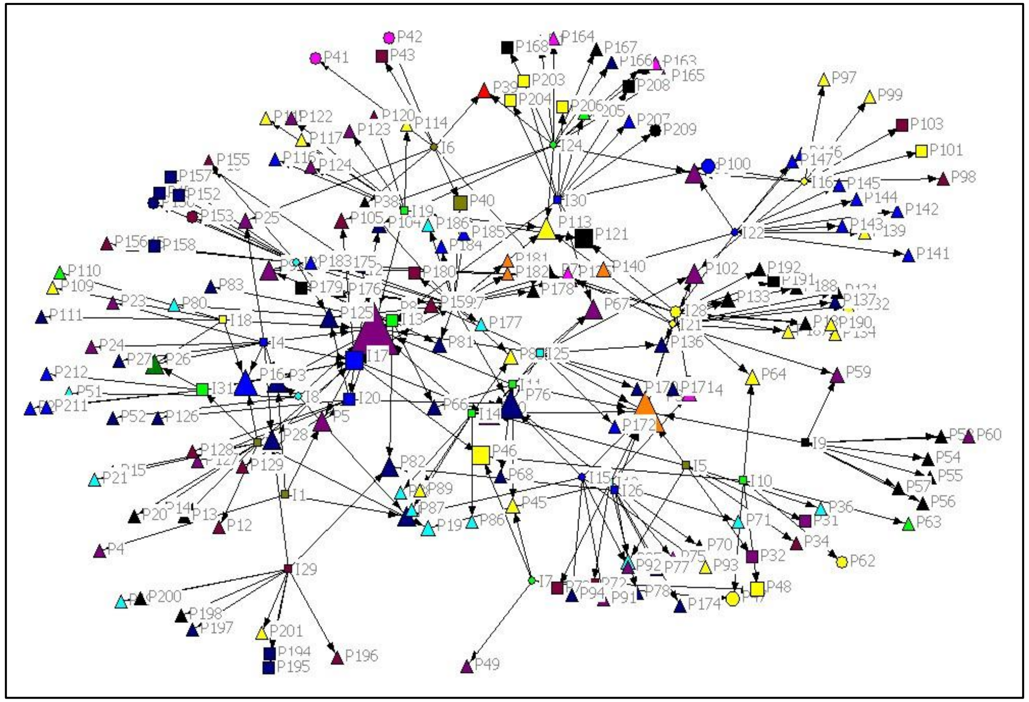

Figure 3: Access networks (left) for climate information in the Orange case study (Harman et al 2016)

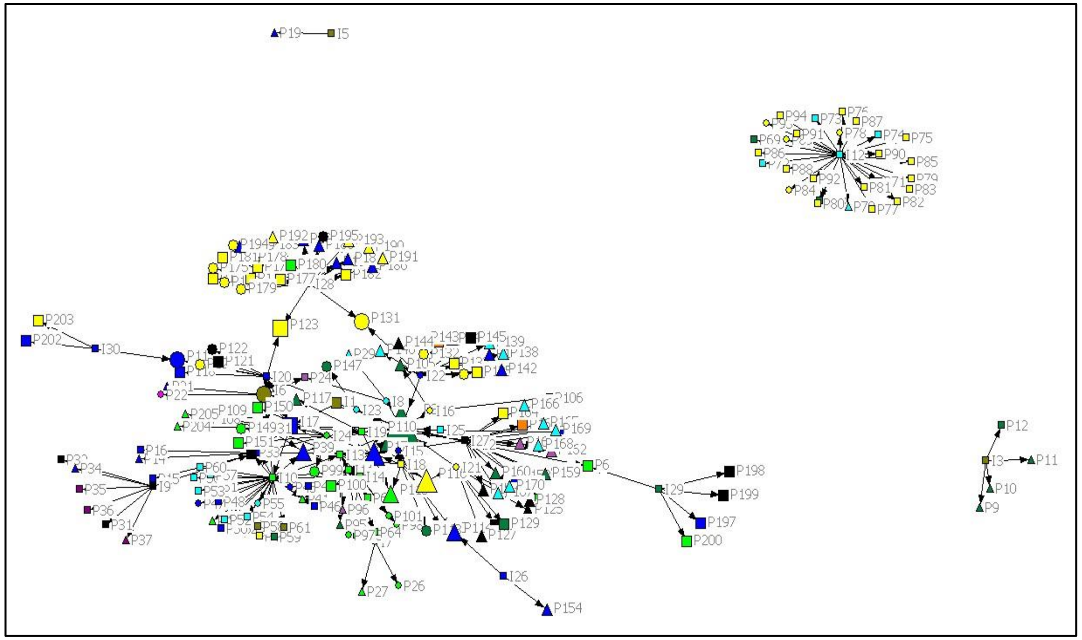

Figure 4: Share networks (right) for climate information in the Orange case study (Harman et al 2016)

4 Social Network Metrics

Appreciation of the value of the NSW case studies requires a basic understanding of network metrics. Social network analysis is a highly specialised branch of mathematics and requires application of sophisticated algorithms to relational matrices of network members. However, once the network has been analysed, some simple measures can be applied to understand how well a network might function for a particular purpose (Table 1). These measures allow users to understand aspects of network cohesion, which determines the ease of information flow through a network.

Table 1: Some key metrics for the Orange social network

	Access network	Share network
Ave degree	1.316	1.185
Density	0.006	0.006
Fragmentation	0.990	0.978
Closure	0.106	0.107
Diameter	3	8
Key players	#17 CBO	#28 State Government
(Interviewees)	#22 State Government	#12 NGO
	#30 State Government	#17 CBO
Percentage nodes reached	35%	49%

Average Degree - measures the average number of links for each node in the network. Links may vary considerably among nodes. For example, in the NSW case studies, individual network members may have identified anywhere from one to dozens of information sources they access on climate adaptation. Similarly, they may share information with many other network members or with no one. In the Orange network the average degree was similar for both access and share networks with the number of links slightly greater than 1 in each case (Table 1).

Density – is the total number of connections divided by the total possible number of connections in the network. For example if there were 10 people in an office, and each shared information with all nine others, the density of the network would equal 1 (high density). Obviously as a network grows, it becomes harder for everyone to be connected to everyone else. Knowledge flows more readily through a high density network. However, high density is not always an advantage, as in very dense networks ‘misinformation’ can also spread easily and become rapidly normalised. This can potentially lead to widespread acceptance of misinformation among network members. In the Orange share and access networks, density was relatively low at 0.006, an indicator of poor network connectivity (Table 1).

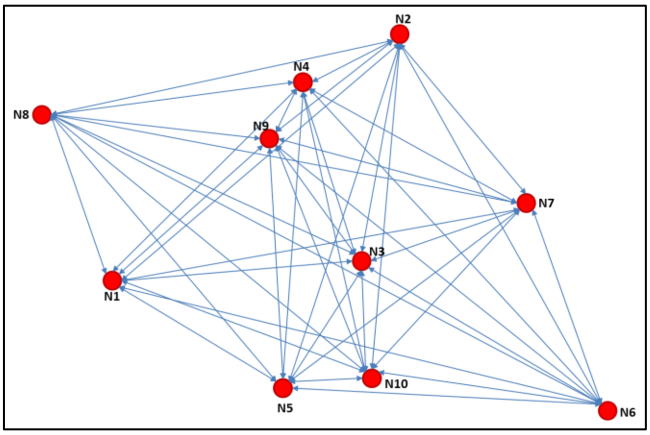

Figure 5: Example of a dense network

Fragmentation – is a measure of the lack of connectivity in a network (Figure 5). The more fragmented the network the more difficult it is to influence. For example, if there is inaccurate policy information in a network it requires a greater effort to contact every individual within that network to correct the misinformation. Within a network that is less fragmented, a new or corrected piece of information can flow more easily. The concept of a 'contagion' borrowed from epidemiology explains this process (Christakis & Fowler 2013). In the instance of flu, for example, a highly fragmented network is ideal as members are less likely to come into contact with an infected member and spread the contagion (see VAX - https://vax.herokuapp.com/faq online tool). However, in the case of new information or a new policy to be embedded in a region, a less fragmented, or more cohesive and dense, network is desirable, as this improves the efficiency of information flow through the network. Most networks, as in the case of the Orange share network (Figure 4), show partial fragmentation to some degree, that is, some parts of the network are better connected than others (Figure 6).

Closure - measures the degree to which "the friend of my friend is likely to be my friend". This measure counts the number of triplets or triads divided by two. The higher the number, the more likely it will be that two people will know a mutual third party. For example in Figure 6, N7 is connected to N3 and N10. Using social network theory, closure indicates that it may be possible, indeed is likely, that N3 may come into contact with N10 due to their mutual connection to N7. While closure is a useful measure, it is difficult to apply to the Orange networks because the nodes in the network were both people and things (such as newspapers, web sites and other media channels).

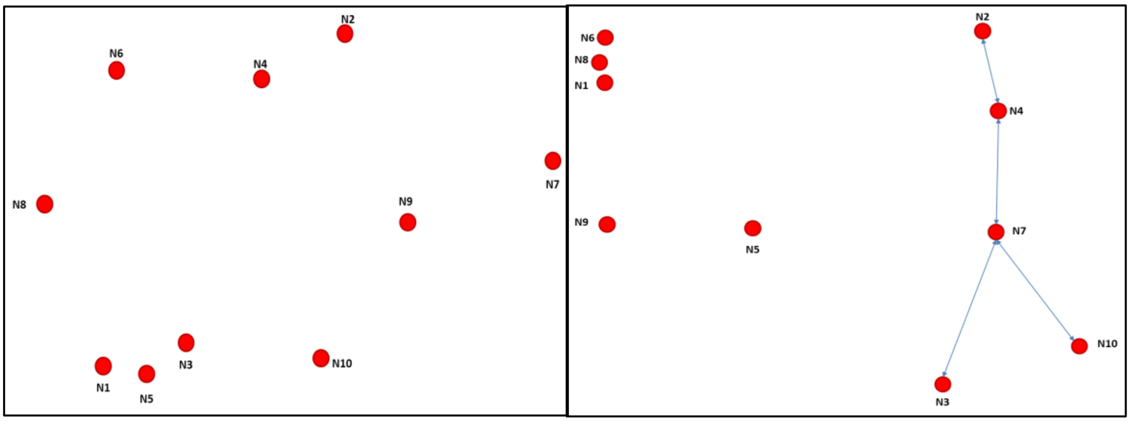

Figure 6: Example of full network fragmentation (left) and partial network fragmentation (right)

Diameter – is a measure of the operation of "6 degrees of separation" or *Bacon's Law* (everyone in Hollywood is connected in a network to actor Kevin Bacon by 6 steps or less, see www.oracleofbacon.org). The diameter measures the number of steps (nodes) it would take to move across the entire network. That is, the more sparse a network the greater the diameter; the more cohesive the network the smaller the diameter. For Orange, the access and share networks showed diameter values of 3 and 8 respectively, indicating that the information access network was more cohesive than the share network.

Importance of Key Players

Key Players are individuals (nodes) in the network with the greatest reach and influence through the network. Analysis of key players is performed through an additional package of algorithms (Keyplayer©) designed specifically to find the optimal route through an entire network (Borgatti, 2006). Key Players may perform different roles depending on the type of network being examined. For example, within a formal organisation, a key player may be a person in an executive role central to operations, or one or more individuals well-linked within the network (see Borgatti, 2006 for further empirical examples). In the Orange access network, three nodes were identified as Key Players (information sources): one was from a community based organisation and two were employed within the NSW Government.

Value of complimentary qualitative analysis

Factors other than network cohesion also determine aspects of network behaviour. For example, the history and norms of the communities in which the networks are embedded can also affect network behaviour. These attributes are difficult to assess from the quantitative metrics described above. Again we will use the Orange case study to illustrate the value of qualitative analysis to compliment quantitative SNA.

A qualitative finding unique to the Orange case study was the high proportion of nodes in the access and share networks that represented NSW Government staff. This finding likely reflects the presence of the head office of the NSW Government's agriculture agency in the region.

Qualitative analysis in Orange revealed the importance of both formal and informal networks for effective knowledge sharing around climate adaptation policy. Participants in each case study reported accessing information from formal networks. This was supported by the Keyplayer© analysis that identified the importance of formal ties to organisations such as Bureau of Meteorology (BOM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for accessing climate adaptation information – particularly in Shoalhaven and Bega. However, in each case study, Keyplayer© analysis also revealed informal networks that were critical in transmitting climate adaptation information. Informal networks in this instance have been classified as individual community members and community based organisations (CBOs) that operated outside formal government networks.

Pelling et al. (2008) discuss informal networks as 'shadow spaces' for social learning (or learning from each other). While connections to recognised climate organisations were important, the three regional case studies suggested that it was through these informal settings that much of climate adaptation information was shared.

One unexpected finding from Orange was the presence of an isolated 'clique' within the share network. An isolate is a node that has no other connections. An isolated clique is a small cluster of nodes within, but unconnected to, a larger network. Qualitative interviews conducted in Orange revealed that the isolated clique visualised in the upper right corner of the share network (Figure 4) represented a specific agricultural industry (in this case the wine industry). Wine producers (the nodes in the clique) had developed a small share network largely independent of the larger share network (i.e. they exchanged information with only the few nodes within the isolate). However, many agricultural industries such as the wine industry have independent, well-organised knowledge networks, often through formal research and development corporations, that support their producers' information needs. This suggests that membership of the larger share network for the wine producers in Orange was not essential to information flow about climate adaptation. Moreover, these wine producers were not sharing information on adaptation with the larger network ('industry insulation'). This is an example of the need for tailored messages to various audiences, as in some instances policy messages disseminated through mass communication channels may not reach isolated groups despite the presence of a relatively cohesive network. It also suggests that some groups in the Orange community are more self-sufficient than others when it comes to information to support adaptation.

By bringing together the quantitative analysis from each case study and the qualitative stories from the interviews in each place, an Adaptation Policy System of knowledge flow within New South Wales emerged. Figure 7 presents this system in terms of two policy spaces: ideation and implementation. The ideation space involved the Australian Government, largely through its role in funding research (such as the agricultural research and development corporations, CRCs and the National Climate Change Adaptation Research Facility) and research organisations such as CSIRO, universities and state government researchers and decision makers. The information generated from formal research processes in 'ideation' informed policy formulation in the implementation space. Implementation primarily involved action by state and local government in collaboration with civil society to develop and implement adaptation policy relevant to local context.

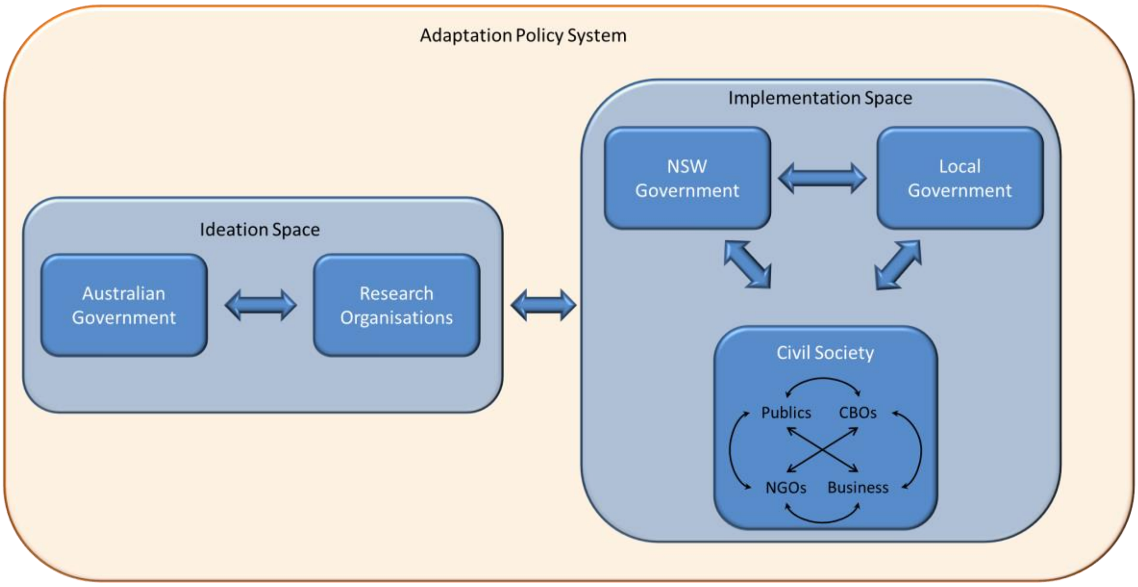

Figure 7: NSW adaptation policy knowledge network model

5. Where to next for SNA?

Climate change will remain one of the greatest challenges for the 21st century and current and future generations will experience unprecedented impacts (see Climate Change in Australia). Our case study research represents a first step in the application of SNA to an improved understanding of community engagement on policy that goes beyond climate adaptation. Some additional areas for research are suggested:

1. Policy dissemination by traditional communication channels through formal knowledge networks may not reach the intended audience. Policy communication generally could be improved through greater use of informal networks, often invisible to centralised government policy-makers particularly in regional communities. SNA is a useful technique to reveal these networks and make them more accessible to community engagement staff.
2. The information networks described in the NSW case studies consisted mainly of adaptation actors involved in the agriculture, natural resource management and environment sectors of the community. These sectors are generally early to adapt as they are intimately affected by climate change and most likely to engage with adaptation knowledge. Other sections of the community appear to be located outside these adaptation networks as they failed to appear as nodes. For example, the education and cultural sectors are integral to the societal fabric of regional communities. Opportunities exist to provide alternative interpretations of climate information for use by this greater range of actors to extend the knowledge networks into currently untapped parts of the community.
3. The New South Wales Government launched a new climate adaptation policy in 2017. This policy launch presents a unique opportunity to monitor the impact of policy implementation through a mixed methods approach to SNA that includes media analysis (tracking the newspaper reports of the policy, both positive and negative), interviews with stakeholders (exploring the local knowledge of the policy, and grassroots implementation using social network analysis) and the assessment of the 'stickiness' of the policy on social media (Twitter analysis).

6. Key literatures, software and training

For a comprehensive introduction to SNA and its applications:

Prell, C. (2012). Social Network Analysis: history, theory & methodology. London, SAGE Publications Ltd.

For an advance course:

Borgatti, S, P; Everett, M. G, Johnson, J, C (2013) Analysing Social Networks. London, SAGE Publications Ltd.

Additional papers outlining the importance of network analysis:

Barabasi, A.-L. and R. Albert (1999). "Emergence of Scaling in Random Networks." SCIENCE **286**: 509-512.

Borgatti, S. P., et al. (2009). "Network analysis in the social sciences. ." SCIENCE **323**: 892 –895.

Dowd, A., et al. (2014). "The role of networks in transforming Australian agriculture." Nature Climate Change **4**(558 – 563).

Additional information for SNA Training and Software:

Software packages UCINET & KEYPLAYER made by Analytics Technologies
http://www.analytictech.com
Free 30 day trial available

Training is available annually at the International Network of Social Network Analysts conference “SUNBELT” http://insna.org/archives.html. Alternatively at the LINKS summer workshop in the USA https://sites.google.com/site/linkscenterworkshopsna/ or the Essex Summer School in the UK http://essexsummerschool.com/summer-school-facts/courses/complete-2016-course-list/2d/

General Social Network analysis training is available online via a MOOC through Coursera https://www.mooc-list.com/course/social-network-analysis-coursera

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