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The impact of climatic hazards on social network structure: insights from community support networks in Western Uganda

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The impact of climatic hazards on social network structure: insights from community support networks in Western Uganda

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Abstract

Social support networks are considered important coping mechanisms in the literature, however not all households experience the same levels of inclusion in these networks. Understanding how support networks vary across climatic shocks is necessary to ensure that adaptation and development policies do not erode access to networks but few studies have investigated this phenomenon. We contribute to filling this gap by exploring social networks in two Ugandan communities during floods, droughts and non-climatic stresses. We use social network analysis (SNA) to examine the structures of different support networks, and the ties that exist between households. We find (1) support networks differ depending on the stress experienced; (2) networks are characterised by bridging social ties with little evidence of bonding social ties and (3) core households that provide support within the networks typically hold formal positions in village institutions, mediating access to both formal and informal support structures. Using SNA to study social support networks under climatic hazards suggest social ties are not as dependent on bonding ties as existing literature suggests. Our findings have important implications for adaptation and development policies and programmes that seek to maintain and develop community support structures, particularly those dominated by informal ties.

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1 Introduction

Individuals, households and communities across sub-Saharan Africa are affected by climatic hazards such as floods and droughts and respond to them through strategies including crop diversification, labour exchange, selling assets, and migration (Chuku and Okoye 2009; Thornton et al. 2007; Adger et al. 2003). Fundamental to these strategies are relations of trust, reciprocity and exchange, more commonly known as social capital (Adger 2003; Woolcock 2001; Lyon 2000), which enable and enhance the coping capacity of rural livelihoods. However, there is still limited understanding of how the social ties that provide access to this social capital are shaped.

Social capital has interested scholars in organisational management (Lee 2009); social anthropology (Putnam 1995) natural resource management (Brondizio et al. 2009), and its importance is increasingly recognised in climate change adaptation research (Adger 2003; Pelling 1998). Recently, a developing body of literature has sought to increase understanding of adaptation through analysing the pattern of relations, or social networks, which result from people's interactions. This has provided insight into community leadership (Bodin and Crona 2008), adaptive co-management (Sandström and Rova 2010), and resilience (Cassidy and Barnes 2012) as well into stakeholder selection (Prell et al. 2008). We contribute to this literature by examining community social network structures under different climatic hazards. We use social network analysis (SNA) (following Barnes-Mauthe et al. 2013; Ramirez-Sanchez and Pinkerton 2009), to examine the effect of climatic hazards on community networks and the ties in two rural communities in Uganda. Network structure is not only important for coping, but also for shaping local natural resource governance systems (Bodin and Prell 2011). However, such structures vary across contexts: network density, cohesion, relations, and structural patterns shape whether networks can support or constrain the activities of different individuals (Bodin and Crona 2009).

Community social networks can facilitate adaptation, particularly to unforeseen environmental changes (Tompkins and Adger 2004). Two distinct types of network relations are identified within the social capital literature: bonding ties tightly connect actors and often result in dense networks amongst family, friends and neighbours (Newman and Dale 2005), whilst bridging ties are found between weakly connected groups (Bebbington 2009; Putnam 2000). Bonding ties have been highlighted as important for coping with weather extremes (Adger 2003; Pelling 1998), yet it is also argued that the balance between bonding and bridging is important (Dale and Onyx 2005; Newman and Dale 2005). Therefore, understanding the bonding and bridging ties within rural social networks is important for gaining insight that helps support rural household coping and adaptation.

This paper examines networks in two different communities in Uganda: one a traditional farming community, the other an inland fishing community with a developing market activity base. We explore networks under different climatic hazards within each village, thereby examining the different contexts that lead to particular network structures. Specifically, this paper aims to:

1) assess the characteristics of networks under different climatic hazards compared to everyday networks;
2) examine the bonding and bridging social ties of these network structures; and
3) identify and examine the characteristics of core households within each network.

By examining the structures of bonding and bridging ties under different climatic hazards alongside characterising key households' involvement in the network, we reflect on how different shocks impact the network and what this means for resilience and adaptation under different environmental conditions. Specifically, we distinguish between informal networks – the internal social support network developed through community relations – and formal networks – the network established through externally initiated support programmes. We also contribute to the growing empirical base that adopts social network analysis (SNA) to develop insights into rural livelihoods.

2 Bonding and bridging network structures for coping and adaptation

Individuals, households and communities respond to shocks depending on their vulnerability, resilience and resources (i.e. Engle 2011; Gallopín 2006). In developing country rural communities, such responses are shaped by inter-household relationships, assets, and livelihood activities (Adger 2003). For example, in addition to money lending, selling off assets, temporary relocation and savings, households may rely on extended family and friends for mutual support during droughts (Mogues 2006). Indeed households with greater social connectivity can be more adaptable (Cassidy and Barnes 2012). Therefore, community networks can have significant implications for how a household copes and adapts to different climatic events.

Alongside environmental, economic and political factors, social norms and community structures impact household activities by regulating access to natural, financial, human, physical and social capitals (Scoones 1998; Carney 1998; Ellis 2000). Moreover, social capital is acknowledged to shape households' access to other forms of capital (Adger 2003). Social capital has been extensively researched and a rich literature debating the associated social theories exists (see Bourdieu 1984; Coleman 1990; Putnam 2000; Lin 2001; Woolcock and Narayan 2000). Measuring intangible resources such as social capital is challenging (Brondizio et al. 2009; Bhandari and Yasunobu 2009) and therefore it can be more insightful to investigate specific aspects of social capital, such as the networks and ties of social relationships.

SNA has been used to examine ties between different actors and their implications within different contexts (Burt 1992; Granovetter 1983; Wasserman and Faust 1994). This includes natural resource management scholars who have investigated the information and knowledge sharing mechanisms within different governance regimes or community networks (for example Sandström and Rova 2010; Cassidy and Barnes 2012; Barnes-Mauthe et al. 2013). Despite this, few studies have investigated how floods and droughts impact social networks and the implications this has for future adaptation.

SNA studies of socio-ecological systems draw upon various analytical techniques to unpack the complexity of networked relationships. For example, in their study of coastal fisheries management, Bodin and Crona (2008) measure the connectivity of individual actors using two measures: “degree” (the number of direct ties an individual has) and “betweenness” (the number of times an individual connects two other actors) (Wasserman and Faust 1994). This is useful to explore how individuals may influence a network, thereby offering insights into levels of trust and social learning across a community (Cassidy and Barnes 2012).

Whilst trust and influence amongst individuals in a network is important, the ability of individuals to access new information from outside of a dense network is also important for social learning and coping (Newman and Dale 2005). Burt (2001) distinguishes between SNA measures such as density (the number of ties in a network), which reinforces trust and sharing with bridging or weak ties - and what he refers to as structural holes – which are important for the diffusion of innovative ideas and information. Burt proposed the concept of brokerage to refer to key individuals who connect across structural holes and enable the distribution of novel ideas (Burt 2005). This resonates with Granovetter’s (1973) arguments about the strength of weak ties, the theory that the most novel information in a network is attained by weak ties (i.e. ties that loosly connect two actors, for example, where there is little contact). Connections that are not frequently relied upon are best placed to diffuse new ideas, information and techniques into a network. Other studies have since identified the potential of brokers to contribute towards rural adaptability (Rotberg 2013) although the evidence base remains limited.

Bonding, or common values and shared responsibilities, often occur within homogenous socioeconomic groups that are tightly connected, whilst bridging ties ‘weakly’ connect different groups. Newman and Dale (2005) argue that bonding ties risk hindering network innovation by imposing social norms that restrict novelty, whereas bridging ties facilitate access to more diverse information and resources. It is therefore argued that both capitals are needed: bridging to provide novel techniques to help overcome challenges, and bonding to provide a level of resilience that is capable of absorbing the benefits from bridging ties (Dale and Onyx 2005; Newman and Dale 2005).

Operationalising bonding and bridging ties has helped explore social capital structures, yet the definitions remain broad (Putnam 2000). Bonding ties are commonly described as 'internal', 'homogenous' or 'localised'. Whilst they need not share all these characteristics, they often result in closed, tightly connected networks. Likewise bridging ties suggest more distant connections, although as Woolcock (2001) argues this is essentially between individuals with similar demographics rather than between individuals with substantially different characteristics. Crowe (2007) attempted to overcome these challenges by analysing bonding and bridging links along a spectrum from complete networks through to factional, coalitional and bridging configurations, thus providing more specific interpretations of the different social relations. A third social relation, linking, is often identified in the literature alongside bonding and bridging. Linking ties have been used to define bridging relations between different communities (Crowe 2007) as well as between members of a community and external actors (Sanginga et al. 2007). Linking capital is known to be important in community engagement with formal institutions (Szreter and Woolcock 2004). Indeed individual 'brokers' link actors in a community network to more formal institutions (Lyon 2000). Such 'scale-crossing brokers' are important for linking actors across scales (Ernstson et al. 2010), especially in rural developing communities.

The extent different social ties substitute for each other is of increasing interest to researchers. Different forms and combinations of social ties become important to different groups at different times (Adger 2003; Woolcock and Narayan 2000). Empirical studies within the climate-vulnerability literature have largely focused on marine and fisheries resource systems (for example Barnes-Mauthe et al. 2013; Bodin and Crona 2008; Ramirez-Sanchez and Pinkerton 2009). Studies that research broader rural livelihoods have largely focused on a particular climatic shock or stress. For example, Cassidy and Barnes (2012) studied resilience to drought induced stress in rural Botswana, and Rotberg (2010) explored social networks and coping with floods in rural Bangladesh. These studies have contributed to our understanding of the role of networks in adaptation, yet how such structures vary under different manifestations of climate variability remains uncertain.

We seek to address this gap by comparing the network structures that exist during different climatic events. Drawing on evidence from two different villages helps consider the influence of different livelihood activities and external drivers. This not only provides insights into the structure of rural networks, and the importance of bonding and bridging ties for household coping, but also the impact on future adaptation and resilience. We go beyond studies that have previously explored social capital and adaptation (Rubin and Rossing 2012; Kithiia 2010; Pelling and High 2005) by applying SNA to identify the bonding and bridging structures that exist under different climatic stresses, and how key actors in each community are integrated into these structures.

3 Methods

This paper focuses on two communities in Kasese district in Western Uganda where the population is highly vulnerable to climatic changes, and is subject to both floods and droughts (Oxfam 2008). The villages of Kigando and Kahendero were selected following discussions with key informants (Figure 1). These two villages enable evidence to be collected from locations with different customary and market-based opportunities: Kigando is an agricultural community dominated by arable subsistence farming, whilst Kahendero is an in-land fishing community with a growing market economy. The range of activities undertaken by the households in each village is shown in Table 1: a discussion of the drivers of these activities is provided in Berman et al. (2014).

Table 1. Number of households that undertook each livelihood strategy (and as a percentage in parentheses of all households within each village).

Livelihood strategy	Activities within strategy	Overall	Wet season	Dry season
Kigando				
Crop	Crop farming	28 (25%)	28 (25%)	36 (33%)
Diversified Crop	Crop farming, and other natural resource-based activities or livestock keeping	69 (64%)	69 (64%)	62 (58%)
Service	As Crop or Diversified Crop strategy with additional service-based activities	11 (11%)	11 (11%)	10 (9%)
Kahendero				
Fish	Fishing	30 (16%)	44 (23%)	51 (27%)
Diversified Fish	Fishing and crop farming and/or/ natural resource-based activities	82 (43%)	68 (36%)	59 (31%)
Crop	Crop farming or Natural resource-based activities (or both)	24 (13%)	34 (18%)	35 (18%)
Service	Service-based or Fish/Diversified Fish/Crop strategies with service activity (and other)	51 (27%)	41 (21%)	40 (21%)
No activity	No activity	3 (2%)	3 (2%)	5 (3%)

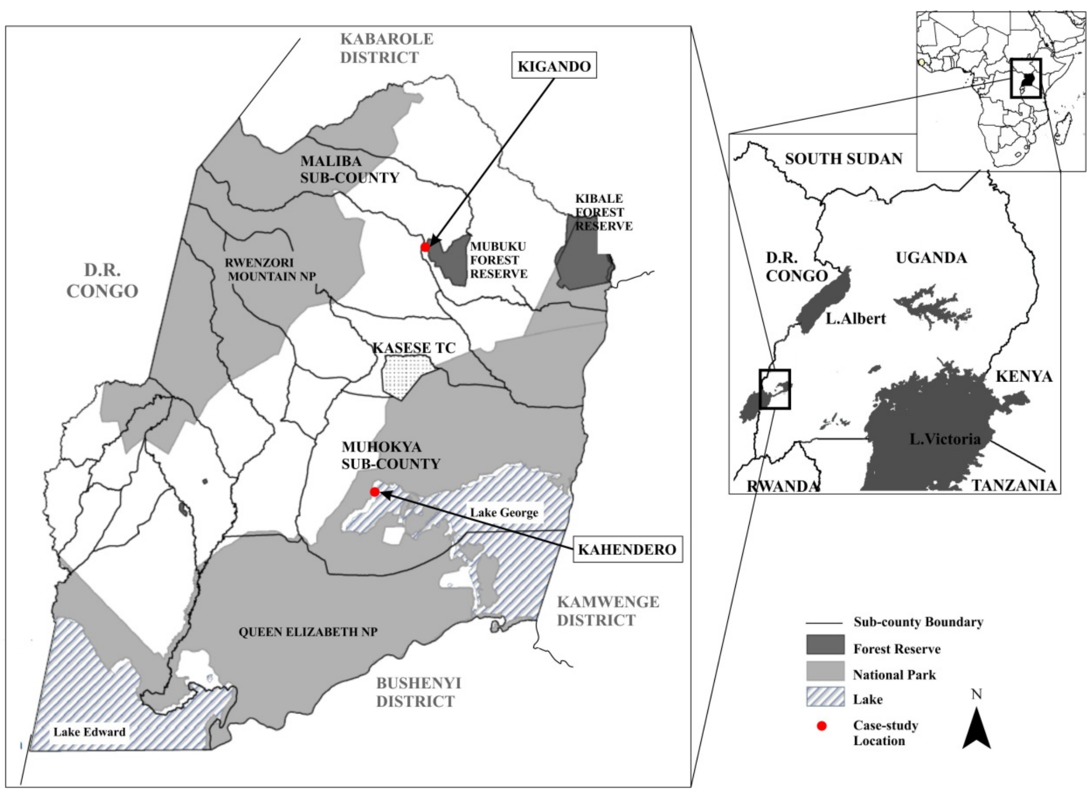

Figure 1. Location map of study sites, Kasese District, Uganda. Spatial data provided by Kasese District Local Government (KDLG 2012)

Fieldwork was undertaken between January and June 2012 in the two villages. A survey targeting all households captured household demographics, livelihood activities and social network data under situations of drought, flood and non-climatic daily stress, thereby providing data on household relations alongside household attribute data. Three questions were asked: apart from members of your household, who provides you with resources or information to enable you to cope when you have a problem that affects your household or livelihood in (a) daily situations, (b) during a flood, and (c) during a drought? For each question respondents were asked to name the relation, and report on the type of information or resource provided and where the relation lives. A support network was developed from the data generated by each question: in each village we analyse a support network for a) daily situations; b) times of flood; and c) times of drought. The network measures analysed are detailed in section 3.1.

As is common across sub-Saharan Africa, the household is the unit where individual's activities combine to create different livelihood strategies (Sallu et al. 2010; Thomas et al. 2007). Therefore our analysis focuses on inter- rather than intra-household interactions. Names of all household members were recorded to enable the social network relations to be matched between households. Absent households and members names were obtained from neighbours. Whilst these were included in the development of the network, in practice many of these households were isolated and were not relied upon by others. We adopt a whole-network approach to capture the pattern of relations across the two villages by interviewing all households (cf. Cassidy and Barnes 2012): response rates were 96% in Kigando (108/112 households) and 76% in Kahendero (190/250).

Household attribute variables were obtained directly from the survey, with the exception of estimated wealth levels. These were computed using Principal Component Analysis (PCA) (as described in Berman et al. 2014), and the computed groups are shown in Table 2. Social network data were collected using the free recall method (Wasserman and Faust 1994) whereby respondents nominated people they were connected to without selecting from a pre-determined list. Whilst this approach generates fewer relations given respondents may forget to recall everyone they gain support from, the reported ties are likely to be amongst the strongest (Prell 2012). Moreover, no complete roster of names was available in the villages for respondents to select from.

Table 2. Distribution of wealth groups

Classification	KIGANDO			KAHENDERO		
	Households (Number)	Households (Percent)	Ave. Wealth*	Households (Number)	Households (Percent)	Ave. Wealth*
Very Poor	39	36.1%	-0.3817	104	54.7%	-0.3990
Poor	27	25.0%	-0.1304	32	16.8%	-0.1377
Moderate	23	21.3%	0.1076	37	19.5%	0.0964
Relatively Wealthy	19	17.6%	1.0164	17	8.9%	2.2913

*Mean scores for First Principal Component

Informal comments made by respondents during the survey were recorded and used to provide further insight to the analysis. Semi-structured interviews were conducted post-survey to elicit further qualitative information. Interview respondents were purposefully sampled to obtain a cross-section of households based on age, gender, education level, wealth, and livelihood activity (n=17 in Kigando and n=19 in Kahendero).

3.1 Data analysis

We analysed data with the UCINET Social Network Analysis Version 6 (Borgatti et al. 2002). Some respondents reported ties with actors outside of the village, although we only analysed network properties within the communities. Direct comparisons between the two villages could not be undertaken due to variations in network size, although comparative interpretation was possible.

To address our first research question on network characteristics, we analysed total number of actors, mean and total number of ties, and degrees of centrality. We identified households that provide support (i.e. directed networks) by using indegree centrality measures. We examined network homophily, the idea that actors prefer having ties with those similar to themselves (McPherson et al. 2001), using ANOVA density model of variable homophily. This tests the probability that within-group tie density differs from between-group tie density (Hanneman and Riddle 2005). We examined homophily based on attributes of livelihood, gender, age, wealth and education. In addition, we ran a QAP correlation to statistically test network variation under different hazards. Similar to standard statistical tests of association (such as Pearson's r), QAP correlation corrects for how correlating network matrices would otherwise violate the assumptions of standard statistical tests (Borgatti et al. 2013).

We analysed network structure following Crowe (2007) who characterises bonding and bridging structures as a continuum, rather than as discrete groups. Network structures can suggest more bonding relationships (complete and fractional) and more bridging relationships (coalitional and bridging). Crowe's framework has previously been used to study bonding and bridging aspects of networks at the community level (Ramirez-Sanchez and Pinkerton 2009; Barnes-Mauthe et al. 2013) and it provides a suitable framework for our analysis. We examined k-cores and cut-points to categorize each network as complete, fractional, coalitional, or bridging (Figure 2). K-core analysis assesses the level of cohesion within a network: a k-core is a sub-group whereby each household is directly connected to at least k other households (Seidman 1983), therefore the higher a networks' largest k-core the more cohesive the network is. We report the lowest value of k shared by all networks in a community in order to compare them (Crowe 2007). Relatedly, we analysed the cut-points within a network, that is households within the social networks that if absent would cause the network to fragment into two or more blocks (parts of a network). This analysis is used to suggest structural holes within the network (Hanneman and Riddle 2005). Whilst linking capital has been evaluated alongside bonding and bridging, we do not examine linking social capital per se. However we do acknowledge the proportion of ties that link to nodes external to the village, and identify the households that broker these links.

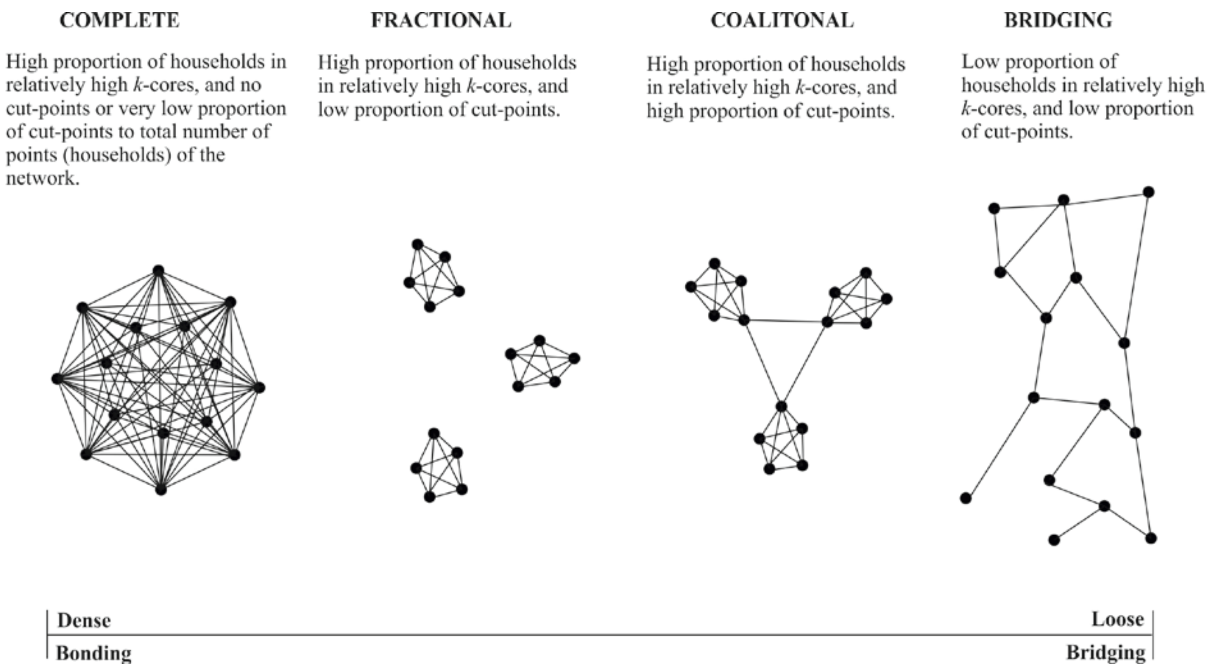

Figure 2. Network structure characterisation as defined through k-cores and cut-points. Adapted from Crowe (2007) and Ramirez-Sanchez and Pinkerton (2009)

Finally, we identify and analysed core households using structural network measures of in-degree and betweenness centrality, based on the assumption that such measures offer a robust way of identifying influential households in a community (Bodin and Crona 2008). Following such studies, we identified households that are ranked as the top ten central households in each network, and define these as 'core' households. Identifying core households through analysing their network position provides a means through which to infer potentially influential households (Wasserman and Faust 1994) but in a manner conducted through community input rather than relying on potentially subjective key informants (Davis and Wagner 2003). Households' in-degree and betweenness centrality scores were ranked and households were scored on:

1) how often the household scored in the top 10 households of all support networks (daily, flood and drought);
2) the number of times they score highest in any network; and
3) the total value of their in-degree and betweenness scores;

Qualitative comments were used to support the characterisation of core households.

4 Results

Network structures under daily, flood and drought conditions are shown for both Kigando and Kahendero in Figure 3. For visualisation, isolated households have been removed from the diagrams although they are still included in the network analysis.

Support networks in Kigando are characterised by the inclusion of various livelihoods, wealth classes and a mix of male and female household heads. The daily network is dominated by a single large component (i.e. all households are connected by at least one tie) with two isolated pairs of households. During floods and droughts, networks are more fragmented. Kahendero's networks -also varied by livelihood, wealth and gender -consist of several smaller components rather than one large component. Similar to Kigando, the flood and drought networks show greater fragmentation. These visual patterns of fragmentation can be quantified through SNA techniques to more robustly analyse social network structures.

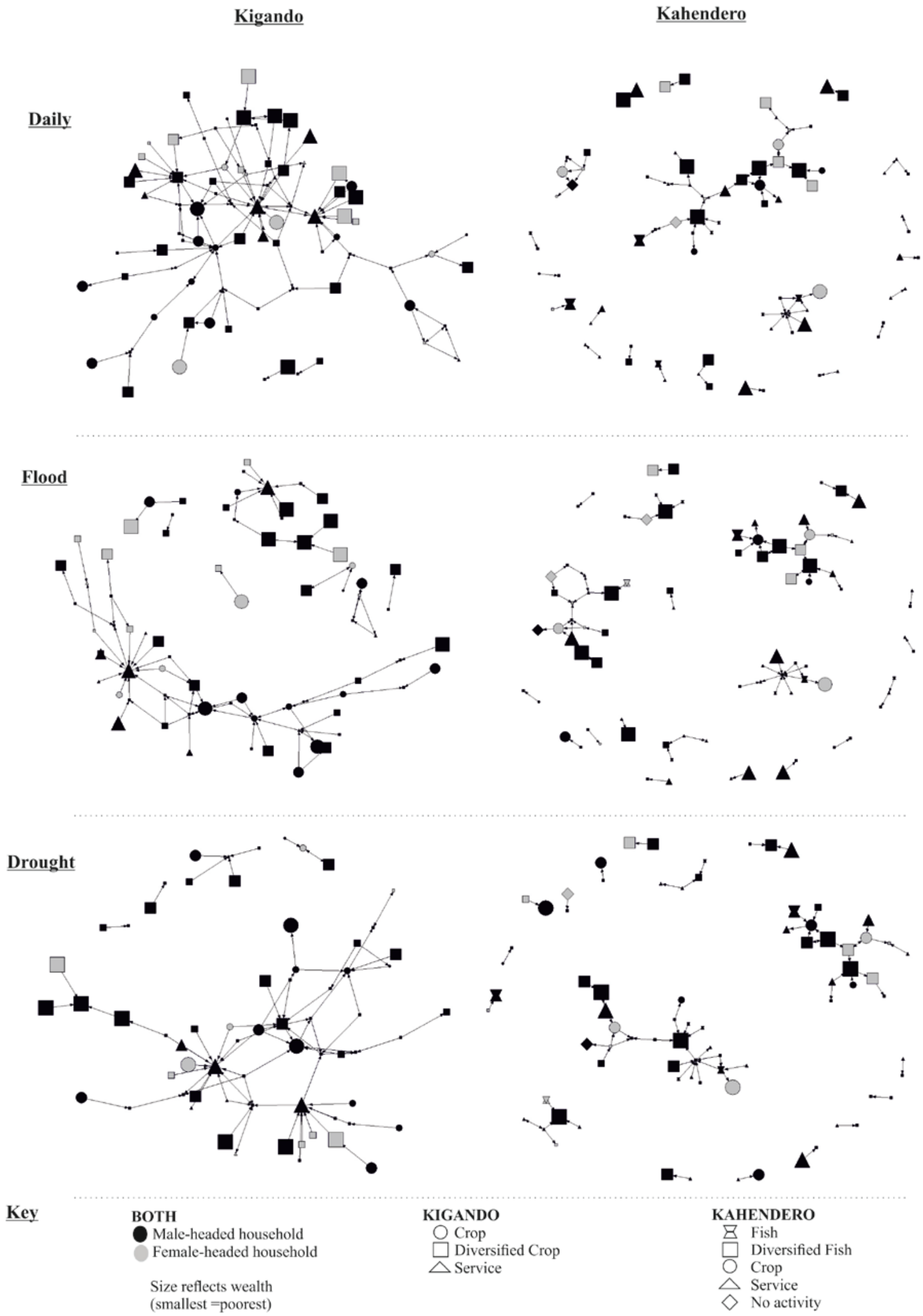

Figure 3. Network visualisation of all daily, flood and drought networks in Kigando and Kahendero.

4.1 Network characteristics

Basic network characteristics are shown in Table 3. Despite a smaller network (n=108), Kigando has more ties across the community than Kahendero, fewer components, and a much higher number of households per component: networks in Kigando are less fragmented. Relatedly, a greater number of households remain isolated in Kahendero's networks. In both villages, similar patterns emerge during hazards: drought networks contain fewer components than the corresponding flood networks (excluding isolates), and therefore can be said to be more connected (i.e. fewer groups enables a more cohesive network). However, when isolated households are considered, drought networks have more components (more households are unconnected with the wider network): fewer households rely on support networks during drought, and there is greater community connectivity during floods (for households involved in the network). The covariance of hazard risk is therefore greater during droughts. Whilst impacts will vary between households during a drought, the stress is uniform across the village and households may be less able to depend on others in the village. However during floods, the network fragments further as households seek support from those not directly affected, or those nearest to them.

Table 3. Summary of network characteristics

	KIGANDO (n=108)			**KAHENDERO (n=190)**		
	Daily	Flood	Drought	Daily	Flood	Drought
Network Data						
Total number of ties	109	80	79	68	75	67
No. of components	30	41	47	129	126	129
No. of components (excl. isolates)	3	9	5	21	20	17
No. of households in largest component	77	45	54	29	16‡	24
Isolated actors†	27 (25%)	32 (30%)	42 (39%)	108 (57%)	106 (56%)	112 (59%)

†Isolated households did not rely on, or provide internal support, and were not considered to determine the bonding/bridging characteristics of each community.
‡ Two components both contained 16 households

Table 4 provides results of the QAP correlation between different networks. In both villages, there is a moderate positive correlation between all networks: networks show elements of similarity across different stresses. However, elements of each network do differ: there is no perfect correlation. Greater similarity is observed between flood and drought networks in Kahendero (0.693) than Kigando (0.597). This correlation can result from households in Kigando only requiring support during one hazard, relying on other coping strategies during other stressors (although QAP correlation does not suggest which hazard is which), whereas in Kahendero, if a household requires support during a flood, they are more likely to also require support during a drought. In addition, the similarity in Kahendero also suggests the same households are approached to provide support during different hazards, whereas in Kigando a larger number of different households are approached during different hazards.

Table 4. QAP Correlation measures between different networks.

	KIGANDO			**KAHENDERO**		
	Daily	Drought	Flood	Daily	Drought	Flood
Daily	1†	0.59†	0.699†	1†	0.599†	0.626†
Drought	-	1†	0.597†	-	1†	0.693†
Flood	-	-	1†	-	-	1†

† significant at $p<0.001$.

Results of the homophily analysis are shown in
Table 5. No attribute shows complete homophily across all networks within a village. In Kigando, homophily is present within the service livelihood and between male headed households across all support networks. For the daily and drought networks, homophily is also suggested among relatively wealthy households. In Kahendero, homophily is suggested among households that have no education. However, no attribute showed homophily across all categories in either village. Therefore households do not necessarily seek support from their 'own kind'. This may be a conscious decision to seek support from someone who is different to them (i.e. different livelihood) and therefore have experienced a different (lesser) impact, or that the factors that characterise those households who are seeking support inherently means the same type of household is unable to offer support. This is revisited later in the analysis of core households.

Table 5. Density of ties by attribute for all households (within group densities presented as percentages). Full between and within group densities for significant results shown in Appendix 1.

Category (n)[§]	**KIGANDO**			**KAHENDERO**		
Livelihood	**Daily**	**Flood**	**Drought**	**Daily**	**Flood**	**Drought**
Crop (28/24)	4%	4%	3%	0%	0%	0%
Diversified Crop (69/0)	3%	2%	2%	-	-	-
Service (11/51)	12%[‡]	9%[‡]	8%[†]	1%	1%	o%
Fish (0/30)	-	-	-	0%	0%	0%
Diversified fish (0/82)	-	-	-	1%	1%	1%[†]
No activity (0/3)	-	-	-	0%	0%	0%
Gender						
Male (84/159)	4%[†]	3%[‡]	3%[‡]	1%	1%	1%
Female (24/31)	1%	2%	2%	2%	2%	2%
Age						
<27 (13/35)	2%	5%	0%	1%	1%	0%
28-42 (36/88)	6%[†]	3%	4%	1%	1%	1%
43-59 (30/42)	5%	3%	2%	1%	1%	1%
60+ (29/25)	1%	1%	1%	1%	2%	1%
Wealth						
Extremely Poor (39/104)	4%	2%	3%	1%	1%	1%
Poor (27/32)	2%	1%	1%	0%	0%	0%
Moderate (23/37)	2%	1%	1%	2%	2%	2%
Relatively Wealthy (19/17)	10%[‡]	4%	7%[‡]	2%	3%	2%

Education						
No education (33/44)	1%	1%	0%	2%‡	2%‡	2%‡
Primary education (61/96)	4%	3%	3%	1%	1%	1%
Secondary education (14/48)	9%†	4%	4%	0%	0%	0%

§Numbers in parentheses represent the number of households in each category (Kigando/Kahendero).
† significance at 10% level.
‡ significance at 5% level.

4.2 Network structure

Results of the K-core analysis for network cohesion and cut-point analysis for structural holes are presented in Table 6. Across all support networks in both villages, the highest value of k is 2: no household gains support from more than two other households in the village. A much greater proportion of households are within a 2-core in Kigando than in Kahendero. Despite this difference between villages, all networks are classified as bridging network structures given the high number of blocks, low proportion of cut-points to total points, and low k-cores (as framed in Figure 2). This also suggests a coalitional structure of Kigando's daily network given the higher proportion of households in the 2-core. No network shows evidence of substantial bonding structures. Bridging network structures suggest there is a much looser connection within the village than would be found in tightly bonded structures. This isn't to suggest tight bonds are not found within the communities, but that such bonds do not characterise the overall network structure during hazards.

Table 6 Summary of network cohesion measures

	KIGANDO (n=108)			KAHENDERO (n=190)		
	Daily	Flood	Drought	Daily	Flood	Drought
Indicators of network cohesion						
Average indegree	13.2%	10.6%	11.6%	3.5%	3.5%	3%
Largest k-core	2	2	2	2	2	2
No. of households that are part of 2-core	46	18	21	4	10	8
Proportion in 2-core	0.43	0.17	0.19	0.02	0.05	0.04
Indicators of structural holes						
No. of cut-points	1	1	1	1	1	1

No. of blocks	40	52	42	56	56	58
Proportion of cut-points to total points	0.01	0.01	0.01	0.01	0.01	0.01
Estimated network configuration	Coalitional/ bridging	Bridging	Bridging	Bridging	Bridging	Bridging

We analyse linking social capital indirectly: informal conversations during the survey suggested low levels of linking capital in both communities with few households reporting direct access to hierarchical support. Examining the internal/external tie relations in the village provides some indication about the support households seek from outside the village. In Kigando, the proportion of households that relied on external support was 19% in the daily network and 18% during floods and droughts. In Kahendero, 28% of households relied on external ties in the daily network, 24% during floods and 25% during droughts. A greater proportion of support is provided from external relations in Kahendero than Kigando (in line with the earlier findings in Table 3, showing fewer internal relations in Kahendero than Kigando) although this does not indicate whether households in Kahendero are unable to access internal support or whether they choose not to. A large proportion of these external ties were to family relations as remittances. In relation to linking capital, external institutional support was largely accessed through key individuals and households within the community that had links to external hierarchal support: village committees reporting to higher levels of government; community based trainers who link to NGOs; and government outreach programmes such as NAADS (National Agricultural Advisory Service). In Kahendero further links exist with private sector outreach and the Beach Management Unit (BMU), which is a government initiated community organisation based at landing sites.

4.3 Core households

We identified ten core households (i.e. those who are most influential in the network) in each village across all three networks (daily, flood and drought). However, when investigating the top 10 households of each hazard, we identified 36 different households in Kigando, and 22 in Kahendero: core households varied across hazards more in Kigando than Kahendero. Less variation in Kahendero suggests core households are approached for support regardless of stress, whereas households in Kigando are targeted depending on the stress experienced. This confirms our earlier speculation from the QAP correlation (section 4.1): fewer households in Kahendero provide support and therefore there is less variation between networks. Nonetheless, core households in both villages vary depending on the hazard: only ten households in both villages appear in the top ten across all three networks.

In Kigando, core households largely reflect the village demography, yet differ in terms of wealth: wealthier households are most likely to hold key positions in social support networks. However in Kahendero, households across the wealth index hold key positions in social support networks. Greater livelihood diversity in Kahendero means that households are not necessarily approached for financial support, but for activity-specific support whilst more homogenous, customary livelihoods in Kigando leads to a greater dependency on households who have more disposable income. Core households typically have more diversified livelihoods or are less dependent on natural resources. These livelihoods better enable a household provide support as typically, not all activities will be affected at once.

Core households often hold broker positions between otherwise disconnected areas of the network, and are therefore crucial in supporting community cohesion. Some also held positions within formally recognised institutions such as village management committees and savings groups, therefore brokering between the village and wider scales. This can inadvertently reinforce the control some individuals have over support networks. Households that struggle to access informal support (such as village networks) may also struggle to access formal support (structured support offered by external actors) where the same households mediate access to both these networks. This was noted by respondents in both villages:

> *"So when I took that issue to them, they [village committee] didn't seem to get bothered or take me seriously because they were friends with the one causing me problems"*

(Kahendero resident, 2012)

"NAADS has come in, but it has been a little bit segregated. Those people who are responsible for allocating resources to us here, they will always want their relatives to be the beneficiaries"

(Kigando resident, 2012)

In summary, results from both communities show that support networks vary under different manifestations of climate variability. In both villages, these networks are characterised by bridging social ties and low levels of homophily. Core households within the support networks are typically wealthier and/or have more diverse livelihood activities than others in the villages.

5 Discussion: Support networks and climatic variability

SNA of community support networks for different climatic hazards shows support networks do vary under different manifestations of climate variability (Figure 3, Table 3 and Table 4), and that these differ compared to support networks that exist for non-climatic stress. This suggests covariance of hazard risk has an impact on network structures. Not only will households approach different households depending on the type of support they require, but also because some households may be only be affected by one hazard and therefore able to offer support during another.

These results resonate with previous studies suggesting that households will activate different social ties depending on the stress experienced (Cassidy and Barnes 2012): under all three stresses (daily, flood and drought) the networks differed in both villages. This is most apparent during floods when networks show greatest fragmentation. Floods cause more immediate and sudden impacts, thus households directly approach those they are certain will assist them. However, drought affects a larger number of households within an area, thereby having a broader impact on the network: more households will be affected by the hazard, thus reducing a household's ability to provide support:

> *"In most cases, when those people are also affected it becomes hard for me to approach them... because I know they have the same problem as I do"*
>
> (Kahendero resident, 2012)

Therefore, whilst flood coping strategies may include greater reliance on social support, the network remains more fragmented as specific households must be targeted. Support networks differ under different hazards both due to the impact of the hazard, and the support required.

Network structure also differed by village: Kahendero's networks were less cohesive than Kigando. Whilst this may result from the variation in network size, other factors also contribute towards this variation. Seasonal population changes in Kahendero due to the fluctuating fish stocks negatively impacts on the creation and maintenance of social ties as not everyone will be contributing towards sustaining such ties (Wilson and Chiveralls 2004). Furthermore, greater fragmentation in Kahendero may also limit opportunities to develop social ties (Putnam 2000) as found in other rural communities (Bodin and Crona 2008). Therefore regular disruption to the networks in Kahendero limits the development of social ties, in turn limiting the use of internal support networks during times of stress. Whilst some isolated households did not depend on the internal network, for example by relying on social ties outside the village, they also were not relied upon by other households in the village (i.e. no incoming ties). It is not possible from the analysis presented here to suggest a typology of networks that characterise particular villages. Development of further empirical studies of community support networks would help to develop an understanding of the pattern of macro network structures that exist in particular rural communities.

Bridging social capital has been found to be less common in social-ecological systems (Goulden et al. 2013). In contrast, our analysis suggests that support networks in Kigando and Kahendero are characterised by bridging ties with little evidence of bonding. Burt (2001) has argued that density and network closure (bonding) maintain and reinforce ideas of trust and reciprocity whilst structural gaps in the network (bridging) are important to access and obtain additional resources, both important aspects for coping. In this argument, households in Kigando and Kahendero show evidence of being able to access additional resources such as new information or physical resources such as replacement crops, but show limited indication that social ties are being maintained in relation to trust and sharing.

Whilst there will inevitably be bonding ties across the community, these are not being significantly drawn upon in the case of climatic hazards. Further evidence for bridging comes from our analysis of homophily (Table 5), in which we found little evidence that households relied on their 'own kind' for support. Relying on homophilous ties has been known to expose a household to greater risk. For example, high levels of homophily amongst natural resource dependent livelihoods will increase a household's vulnerability should such livelihoods cease to function during a particular covariate shock or stress (Osbahr 2007). Therefore whilst households may not be proactively adapting, cross-community tie structures go some way to reduce their vulnerability to climatic hazards.

Networks that are composed of bridging ties have been said to strengthen a community's ability to adapt to change (Newman and Dale 2005) by increasing access to a diverse range of resources. Likewise, networks that only contain bonding ties may reduce resilience through hindering innovation. According to Szreter and Woolcock (2004), both bridging and bonding ties (and linking) are needed to support the effective use of community social capital. Bonding ties have been found to be important for enabling collective action in rural communities, especially through the establishment of common goals and shared norms (Barnes-Mauthe et al. 2013). In Kigando and Kahendero, whilst bridging ties may currently be supporting household coping, a lack of bonding ties across the network is limiting community capacity to proactively increase the overall resilience of their livelihoods to future changes. For example, a lack of collective action in Kahendero is resulting in increased pressure on the fisheries resource, with little action being taken to move towards a more sustainable resource system:

> *"These days it is changed and those that go into fishing, fish for free. They don't consult anybody. We use to consult our elders, but these days, even a child of 14 years starts and he goes…there are no rules to really protect the fishing project."*
>
> (Kahendero resident, 2012)

Therefore, our findings suggest there are cases whereby households can be seen to be 'successfully' coping without the presence of strong bonding ties. Although networks are known to be context specific, especially in relation to a system's resilience (Janssen et al. 2006), these results reinforce the need to not fully focus on the bonding capital in enabling households and communities to cope with climatic extremes. Our evidence suggests a lack of bonding capital across support networks. However this is not to say such social capital is not present or does not exist between individual households, but only that it does not characterise support networks in general.

Core households and the role of brokers

Core households in both villages were generally wealthier with more diverse livelihood activities, although there was no statistical difference between them and the village demographic which is in contrast to other studies (Bodin and Crona 2008). The core households we identified were relied upon not only due to their ability to provide resources in times of need, but because of their ability to (intentionally and unintentionally) influence others, be that through controlling information, or shaping the support others are provided with. Core actors have been found to support community resilience, for example, through disseminating information to others in the network (Isaac et al. 2007), or through helping to represent stakeholders in a network (Prell et al. 2008). Therefore core households are important to consider for coping and adaptation planning: other households are dependent (and vulnerable) to the activities of these core households. Given that demographics did not shape whether households in the two villages held core positions, other household attributes are likely to be responsible.

Core households often held formal roles in village or management committees, or as community-based trainers, thereby acting as important scale-crossing brokers to external formal institutional support mechanisms (Ernstson et al. 2010). These authoritative positions impact on both the informal support networks, but also shape other households' access to formal support (Osbahr et al. 2010). Given these positions of responsibility, households core to both formal and informal networks are not independent of each other. If a household cannot access formal support, they may depend on informal networks. However, if they are isolated from the informal network but still require support, they may be unable to access formal networks given substantially fewer households have links to the formal network. Therefore households excluded from informal social support networks face compounded levels of vulnerability from both the occurring climatic hazard, and because of an inability to access support networks.

Where informal support networks are weak, dependence on formal networks (often with clearly defined access criteria such as village savings groups) increases. This echoes arguments by Titeca and Vervisch (2008) whereby linking capital can disrupt community activities, especially where bonding and bridging capital are limited. Core households may therefore readily affect the activities of other households given limited bonding ties in both communities. These core-households can have a negative impact on community activities, thereby limiting some households' capacities to cope with climatic variability. Whilst Rotberg (2013) argues such brokers provide opportunities to strengthen support networks, our evidence raises concerns that such brokers restrict households from accessing support by shaping who accesses and benefits from formal support. However, such households may act as brokers due to their resource availability: wealthier households will most likely be relied upon more often because they should have more resource to be able to cope whilst supporting others. Despite this, some households do benefit from such ties, and linking capital can also complement the activities of these households.

Climate adaptation, social resilience and development policy

Our evidence provides insight into how rural support networks function, and why different hazards might lead to different network structures. This study explored the social networks that exist within recent climatic events. Households must make long–term investments in networks to support both short term coping and long-term reduction in livelihood risks (Osbahr 2007), yet we find no evidence to suggest households are proactively investing in their networks to build their resilience to future changes. Different social ties will become important to different groups at different times (Adger 2003; Woolcock and Narayan 2000). Therefore, the dominance of bridging structures over bonding does not automatically lead to low levels of social capital within the communities in general, but that the dominance of bridging may be preventing the development of trust relations that are required for long-term investments. Again, this does not mean the community is devoid of strong social bonds: strong social relations may exist under other stresses, or where overlooked by the respondents as they do not view the relation as a support mechanism. Studies have suggested that social norms surrounding trust are high within rural communities (Barnes-Mauthe et al. 2013; Bodin and Crona 2009), yet we have found limited evidence for this in the networks we have studied.

Access to support networks and the social capital they afford is increasingly recognised as a form of resilience in natural resource dependent communities (Goulden et al. 2013), and informal networks enable households to cope with short-term climatic shocks. Encouraging inter-household engagement across a village can enhance local adaptive capacity (Osbahr et al. 2010), yet this is not guaranteed. If informal support networks are to contribute towards increased household resilience, investments in building long-term relationships are needed. Whilst bridging ties are being invested in to maintain and enhance access to resources for coping, there is little evidence to suggest investments are being made in networks to build increased resilience to future changes. For example, there was limited evidence that investments in trust and reciprocity during times of climatic hazards in the villages were being made. Therefore, adaptation and development policy initiatives may easily influence community structures where there is low bonding, but such initiatives must carefully consider the future implications that any policy or programme will have on community social structures, and whether they risk undermining the functioning of such structures.

This limited investment in future networks may result in part from the culture of consensus building and respect for social hierarchies that are ingrained within local forms of participation in Uganda (Roncoli et al. 2011). Therefore unless village leaders are seen to invest in trust and practises of reciprocity, few other households will. Khayesi and George (2011) have also suggested that reciprocal norms can have negative effects on a network. If a household is to invest in the network, there needs to be high confidence that their investment would be reciprocated in the future. As Inkpen and Tsang (2005) argue, this can lead to an unwillingness of actors to experiment with the network. This challenge is exacerbated through the respect for social hierarchies within such cultures. Whilst households invest to enable short-term coping, the deeper investments needed for future adaptation are not apparent. Identifying and supporting processes that enhance trust building can help develop longer-term network structures that aid household resilience.

Both internal and external networks have implications for future household vulnerability. Some households invest in only one of these networks, therefore remaining vulnerable if that network collapses (Osbahr 2007). However, other households invest in both internal and external networks, although membership to one can determine access to the other. For those unable to access external networks, complete reliance on internal support leaves households vulnerable when a covariate shock affects the whole community and disrupts network functioning. Similarly, if an external network fails and a household has not invested in informal village networks, they risk being left unable to engage in such networks. Therefore both informal and formal networks need investment to provide households options during times of stress. If households remain unable to access multiple networks, inequalities may become exacerbated and restrict households from building resilience to future change.

6 Conclusion

We have used SNA to empirically investigate the impact of climatic hazards on the structure of community support networks. We have shown (1) support structures are hazard specific; (2) bonding social ties are not always relied upon during times of coping; and (3) core households are largely representative of the wider village demographic, often acting as brokers to other ecological scales and formal institutions.

There is small yet developing literature that examines network structures within socio-ecological systems. So far such studies have largely focused on governance systems for collective action and natural resource management rather than on coping or adapting to system shocks. We have provided insight into the characteristics of network structures that are relied upon during times of coping with evidence from two differing rural contexts. Whilst both communities use support networks to cope during times of floods or droughts, neither showed evidence of using the networks to support longer term adapting. In particular, whilst bonding ties have been extensively argued as important for coping with climatic hazards, both communities exhibited greater bridging ties compared to bonding ties. We suggest this has significant implications for the ability of communities to proactively build resilience towards future changes. Bridging ties may be enabling households to access resources to cope with changing situations, but there is little suggestion that households are investing in bonding ties and relations of shared norms and collective action, that may help overcome unexpected changes.

SNA studies for adaptation are still in their infancy. This study has drawn upon frameworks and methods used in similar studies to enable results to be comparable with existing work. Of significance from our study is that rural networks with few bonding ties can still be used to cope with climatic hazards, and also core households (acting as brokers) can negatively impact on other households' coping capacities. Despite this, we recognise that other studies have shown the importance and positive function core households can play in adaptation, as well as the importance of bonding ties. Extending this study to examine support in other communities would help to explore whether such findings are more commonplace than has previously been reported, and if so, what the implications or reasons may be. This would have substantial implications for adaptation and development policies and programmes that seek to maintain and develop community support structures, particularly those dominated by informal ties.

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Appendix 1 – Homophily analysis: within and between group densities for significant results

Tables show within and between group densities. Homophily is found when within group densitites are greater than between group densities. Where this is statistically significant, results are shown in bold.

A. 1 Kigando

Livelihood strategy

Category (n)[§]	Daily			Flood			Drought		
Livelihood	**Crop**	**D.Crop**	**Service**	**Crop**	**D.Crop**	**Service**	**Crop**	**D.Crop**	**Service**
Crop (28)	0.041	0.022	0.068	0.037	0.016	0.043	0.028	0.016	0.059
Diversified Crop (69)	0.022	0.026	0.106	0.019	0.016	0.087	0.014	0.019	0.082
Service (11)	0.012	0.035	**0.121**	0.012	0.014	**0.091**	0.000	0.027	**0.083**

Gender (of household head)

Category (n)[§]	Daily		Flood		Drought	
Gender	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Male (84)	**0.041**	0.017	**0.030**	0.012	**0.032**	0.009
Female (24)	0.033	0.007	0.017	0.022	0.020	0.000

Wealth

Category (n)[§]	Daily				Flood				Drought			
Age	**EP**	**P**	**M**	**RW**	**EP**	**P**	**M**	**RW**	**EP**	**P**	**M**	**RW**
EP (39)	0.043	0.028	0.019	0.059	0.019	0.028	0.022	0.053	0.031	0.018	0.017	0.058
P (27)	0.032	0.016	0.029	0.058	0.031	0.009	0.013	0.072	0.025	0.006	0.013	0.060
M (23)	0.037	0.016	0.022	0.073	0.018	0.018	0.008	0.041	0.019	0.014	0.008	0.043
RW (19)	0.015	0.014	0.018	**0.094**	0.018	0.008	0.000	0.044	0.028	0.000	0.000	**0.067**

EP (Extreamly Poor), P(Poor), M (Moderate), RW (Relatively Wealthy)

Age and education are not shown due to limited homophily across attribute.

A. 2 Kahendero

Education

Category (n)[§]	**Daily**			**Flood**			**Drought**		
Age	**N.E**	**1e**	**2e**	**N.E**	**1e**	**2e**	**N.E**	**1e**	**2e**
N.E (44)	**0.016**	0.004	0.004	**0.023**	0.007	0.004	**0.018**	0.007	0.000
1e (96)	0.009	0.006	0.004	0.011	0.008	0.005	0.011	0.007	0.003
2e (48)	0.011	0.009	0.003	0.009	0.007	0.000	0.010	0.008	0.000

N.E. (No education), 1e (Primary education), 2e (Secondary education)

Livelihood, gender, age and wealth are not shown due to limited homophily across attribute.

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