How to design local adaptation strategies: a network approach to natural hazard and resource management

Karin Ingold, Political Science Institute, University of Bern¹, Oeschger Center on Climate Research, University of Bern, and Swiss Federal Institute on Aquatic Research and Technology (EAWAG)

Jörg Balsiger, University of Geneva, and Swiss Federal Institute of Technology (ETH Zurich)

Current research on the prominent issue of climate change increasingly suggests that global changes have multiple local effects. This raises the question of how local communities should adapt to such changes. Several policy scholars claim that the concepts of social capital and its development are important factors that might explain the quality of local climate change adaptation.

Here we address the concept of social capital, adopting a network approach: the quality of relations among actors in policy-making as well as the frequency of interactions between them are assessed as proxies of social capital building. More specifically, this paper points out the relevance of relationship quality and direction when investigating transformations of structural settings among individuals in general, and actors involved in policy processes in particular. It investigates the question of whether the presence of information ties (defined as a directed relationship) leads to the creation of collaboration relations (defined as an undirected and mutual link between two actors).

To answer this question, a preliminary investigation of information and collaboration networks in six different case studies is presented here: the first set of case studies considers three natural hazard prevention projects in Swiss mountains; a second set considers three bottom-up natural resource management concepts. We claim that the issue of social capital is relevant in these two specific settings where short-term responses must be combined with long-term strategies. Preliminary results show that information may lead to collaboration. No differences between social capital performance in top-down (natural hazard) and bottom-up (resource management) designed projects were observed.

¹ Contact information and affiliation:
Prof. Dr. Karin Ingold, Institute for Political Science, University of Berne, Lerchenweg 36, 3000 Bern, Switzerland; karin.ingold@ipw.unibe.ch
1. Climate change adaptation and the involvement of local communities

The goal of this research project is to investigate how local communities adapt to climate change, in particular the design and implementation of natural hazard prevention and resource management. It focuses especially on structures of adaptation processes and investigates the creation of sustainable relations among involved stakeholders as a proxy for social capital building.

Climate change adaptation requires a particular policy design because the sources of the problem are often global; the effects of climate change, however, are mostly regional and local in nature. From a normative point of view, this multi-level nature of climate change necessitates the integration of national, sub-national and local stakeholders when it comes to the design and implementation of adaptation policies. The process and impact of climate change thus requires adaptation predominantly within and of local communities. But how are adaptation structures built?

On the one hand, climate change effects can be severe and short-term; one might think of extreme events such as floods and heat waves. This context challenges the political system, as rapid and effective policy solutions, such as evacuations, emergency plans and immediate infrastructural adaptation are needed. On the other hand, changes also occur incrementally and natural hazards may be difficult to anticipate. This second characteristic of climate change effects thus calls for long-term and sustainable adaptation structures. Environmental governance and social capital scholars highlight the importance of knowledge transfer (Walker et al. 1997), the creation of trust (Coleman 1990), and learning processes (Newig et al. 2010) in formulating short-term responses and long-term strategies. This article contributes to that literature through a formal social network analysis, focusing on policy structures and the characteristics of local policy networks.

To date, adaptation and resource management policies have often been analyzed through the lens of multi-level governance. Conceptual tools have been developed to study collaborative modes of governing (Ingold et al. 2010; Bolleyer and Börzel 2010; Lubell and Fulton 2007; Scharpf 2001), horizontal actors’ integration where political authority can be reallocated laterally from the state to non-state actors (Hooghe and Marks 2003), and non-hierarchical and negotiated exchanges between different types of stakeholders (Bolleyer and Börzel 2010; Eckberg and Joas 2004). Little empirical research, however, exists about what leads to the establishment of strong relationships among actors involved in adaptation and resource management. We therefore precede with a comparative case study of six local adaptation and natural resource management projects in Swiss mountain regions, investigating information exchange and collaboration relations among actors involved in those projects. The major aim of this research is to investigate if information exchange is an important pre-condition for the creation of more sustainable collaborative relationships. The basic
assumption is that collaboration, indicative of a reciprocated relationship, is an important element for building trust and long-term structural patterns among actors. Collaboration networks have the potential to create and foster relations that last longer than the duration of the policy project in which they were built; they thus serve as a proxy for social capital creation and are an important factor with regards to responding rapidly and adapting sustainably to the impact of climate change.

2. Adaptation and social capital: a relational approach

Social capital can be defined as mutually supportive relations in communities that can serve as valuable means of combating many of social disorders (Putnam 2000). The concept therefore seems relevant to climate change adaptation. Climate change impacts can be defined as changes in the natural environment that also have critical effects on the social, economic and political system. The establishment of social capital in communities affected by climate change effects can thus serve as an important condition to create adaptation strategies; it becomes particularly crucial when defining social capital as social relations that can be mobilized to facilitate action (Adler & Kwon 2002).

Social capital can be criticized for being an “umbrella concept” (Hirsch & Levin 1999) or “a wonderfully elastic term” (Lappe & Du Bois 1997, 119); we therefore apply here a relational approach and thus borrow definitions from social network analysis to investigate social capital as a structural concept. We thus follow Adler & Kwon’s (2002) definition that social capital sources lie in the social structure within which actors are located. It is not our intention here to investigate social capital as a dependent or independent variable; rather we are interested in the investigation of structural and relational patterns that can be seen as proxies for social capital within local communities. Following Evans (1996) and Ostrom (1994), we focus here on internal ties within a given society, specifically within a given policy process formulating and implementing policy solutions for climate change adaptation.

Several scholars have studied the structural arrangement within networks in general and policy processes in particular. As outlined by Adler & Kwon (2002: 24), probably the most prominent contributions were made by Coleman (1990; 1988) and Burt (1992). The former argues that closure of the network, and thus increased interconnectedness among actors, leads to trust-building and effective norms, and thus strengthens social capital within a given community or process (Coleman 1988). Burt, in contrast to Coleman’s focus on closure, argues that strong ties might be constraining and that the potential for social capital lies in weak ties (Burt 1992). Weak and sparse ties facilitate information flow and the diffusion of innovations which then has a positive impact on brokerage and the creation of links among groups of actors that would otherwise not be connected.
In our research, based on the assumption that climate change adaptation is a long-term phenomenon, we are interested in the dynamics that might exist between weak and strong ties. It is thus not the intention here to investigate a causal link between structural patterns and social capital creation, but rather to assess what structural pre-conditions may lead to network structures that can be activated in situations where short-term reactions and long-term adaptation are needed. Expressed differently, we ask the question: if the presence of weak ties may lead to the establishment of strong ties and following Coleman’s (1988) assumption – therefore to trust-building and structural patterns among actors that allow for (political) action.

We argue that the quality of ties matters; depending on the content of ties, the effect of ties may vary considerably (Burt 1997). Many scholars have noted the importance of communication flow among actors (Granberg and Elander 2007, Tompkins 2005, Jessamy and Turner 2003), but the impact on the whole process, here specifically in relation to social capital building, might be very different depending on the kind of communicative relations at stake. If communication flow is one-way, for instance, two situations are possible (see Ingold et al. 2010). First, if regulators (mostly situated one administrative level above their audience) selectively provide target groups with information about adaptation policies, the process resembles a traditional top-down approach in which local communities hardly have a say in the design of adaptation policies. Second, in formal or informal consultation procedures, communities can only participate if they are asked to do so. In that case, they provide the next higher decision levels with information. Such information relations are typically directed, having a “sender” and a “receiver”, and do not have to be reciprocal, which is why one-way information and traditional consultation can be classified as weak relations. In contrast, strong ties are typically two-way communication relations and are traditionally assessed through collaboration networks. Collaboration is per definition a mutual relationship in which two or more partners are engaged. Collaboration promotes the continuous and collective adjustment of goals, objectives and concrete measures among different actors (see Compston 2009 for a review of different actors’ strategies and communicational types in climate change policymaking). If the frequency of collaborative relations is high, actors are integrated in decision-making processes that can generate long-term solutions to climate change adaptation and high local adaptive capacity.

Newig et al. (2009) have classified different relational types and conclude in their study about learning in governance networks that information transmission appears to be an important condition for the resilience and capacity of a network to remain intact over time. We deduce that information (defined as a weak, directed, and one-way relationship) can serve as a pre-condition for the establishment of relationships (measured by extent of collaboration, defined as an undirected and
mutual link between two actors)) that in turn allow for a reproduction of the network, which may be important in climate change adaptation.

H1: Within local adaptation and resource management projects, information exchange leads to collaboration relations.

3. Process design matters

Most natural resource management studies that concentrate on relational patterns are interested in the organization of local communities (Ostrom 1994). Hirschi (2010) and Ingold et al. (2010), for instance, demonstrate that regional cohesion and horizontal and vertical actors’ integration in policy networks matter for the enhancement of sustainable development and long-term collaboration in local rural areas. Prell et al. (2007) apply a social network analysis as a preliminary step for the design of participatory and collective decision-making processes among stakeholders involved in local resource management. Furthermore, Lubell & Fulton (2007) convincingly argue that local networks and interactions among actors matter for the adoption of environmental best practices in watershed management. These studies illustrate the potential of bottom-up processes to build trust and enhance social capital within local communities.

Natural hazard prevention, especially short-term reactions to extreme events, is, however, not always designed in a bottom-up way and is not exclusively implemented through participatory processes with local actors’ involvement. In general, we expect a difference in structural patterns between top-down and bottom-up designed decision-making processes, which is why our second hypothesis is as follows:

H2: Information exchange is more likely to lead to collaboration relations in bottom-up than in top-down designed adaptation and resource management projects.

4. Operationalization through SNA

One major distinction is crucial when assessing social capital through a network approach: one can either focus on relations an actor maintains with other actors, or consider the whole structure an actor is involved. Here, the two dimensions - the actors’ direct relations and the whole network structure - are assessed.
To test if information relations lead to collaboration, we thus investigate both types of ties for each of the six case studies: directed relationships going from one actor (sender) to the other (receiver) and mutual relationships between two actors.

Before correlating the two networks of information and collaboration, we are interested in confirming our basic assumption that information is, in fact, a weak type of tie, and collaboration a strong one. This is investigated using three approaches: first, the comparison of densities within the two networks; second, the assessment of the core/periphery structure; and third, the presence of Simmelian ties and sub-groups of strongly related actors.

Measuring the density of a network means calculating an index of the degree of dyadic connection in a population. For binary data (0 when the relation is absent, 1 when it is present), density is simply the ratio of the number of adjacencies that are present divided by the number of pairs - the proportion of all possible dyadic connections actually present (Hanneman & Riddle 2005). We expect densities within the information network to be stronger than in the collaboration network: weak ties are generally easier to establish than mutual relations such as collaboration ties, and this is particularly true for information exchange. The first indicator that information serves as a good proxy for weak ties and collaboration for strong ones would thus be if the densities of both networks differed considerably, the first being stronger.

The ideal-typical core/periphery structure of a network identifies a core of densely related nodes and a periphery where nodes are only connected to the center, and loosely so. Peripheral nodes are thus not well-connected among each other and the network takes the form of a star (see Scott 2000). In general, one must note that large cores mean that a network is very integrated, and that most actors involved in a process are also well-connected. We thus expect a tendency for bigger cores in the collaboration network: information flow is very easy to establish and does not need reciprocation. More concretely, one can inform an actor about a project without that actor being obliged or willing to give information in return or to establish a mutual relationship. The same is true if an actor feels concerned and gives information to another stakeholder in the core: the core actor can easily ignore the information or just not reciprocate. This situation is very different when thinking about collaboration relations: this is a mutual tie in which – per definition – both actors are involved. It is also in the nature of a political decision-making and implementation process that actors not only collaborate bilaterally, but that several actors become interlinked. This is why we expect cores to be larger in collaboration than in information networks; relative core size is therefore a second indicator for whether information is a good proxy for weak, and collaboration for strong relations.
In a dense network, most dyads are embedded in triads where all three actors are connected with each other. Krackhardt convincingly demonstrated in “Simmelian Ties” and “The Ties that Torture” (Krackhardt 1998, 1990) that a triad can be very constraining, building on Simmel’s analysis of the effects of triads. Simmel (1950) argues that engagement in a three-person group (triad) is much more constraining than in a dyad (a relationship between two actors). The change from a dyad to a triad changes individuals’ behavior, much more than group size does (see Dekker 2006). This is a crucial point in the development and enforcement of norms that facilitate effective means of coordination in groups of three or larger (see also Coleman 1990). Actors involved in triads may be less independent from each other, but a triad also holds the potential for trust-building.

From a conceptual point of view, the existence of triads or even larger groups of densely-related actors makes more sense in the collaboration network where we expect the establishment of sustainable network structures. But we also define information ties as weak relations that should be easier to establish than collaboration ties. Therefore, triads and sub-groups of strongly-related actors are expected to be more often present in the denser information network than in the looser collaboration network.

In summary, the following three indicators would confirm that information is a good proxy for weak relationships, as is collaboration for strong ones:

- Greater density within information networks compared to collaboration networks
- A bigger core within collaboration networks; more equilibrated distribution of actors among core/periphery within information networks
- More extensive participation in cliques and thus larger number of Simmelian ties in information networks than in collaboration networks

To test the two hypotheses -- whether information exchange leads to collaboration (H1) and if so, more often in bottom-up than in top-down designed projects (H2) -- we finally proceed with a correlation of the two ‘actor x actor’ matrices. Furthermore, based on the core/periphery analysis outlined above, we also investigate “core overlap”. This means that we identify actors that participate in the core of the information, as well as in the core of the collaboration network. A large overlap of both cores would also be an indication that information may lead to collaboration. Furthermore, actors in both cores would hold a special position overall and play a crucial role in the policy process.
5. Case studies

Studying climate adaptation in Switzerland is interesting for several reasons. First, Switzerland has, mostly due to its diverse mountain regions, a very particular topographic and meteorological setting. These extreme topographic and ecological conditions magnify the effects of rising temperatures on the frequency of extreme events such as floods and droughts (OcCC 2008; IPCC 2007). This prediction of climate change impacts for the next forty years challenges several sectors and begs for a reaction from the political system (OcCC 2007).

Second, the Swiss political system, characterized by federalism and direct democratic instruments, is well-equipped to address the multi-level nature of climate change in Switzerland. It is an ideal case to study multi-level resource and competence allocation and the inclusion of state and non-state actors in the process of adaptation strategy design.

Six adaptation and natural resource management projects are compared here, four of them belonging to a mountain area in southern Switzerland, two of them from the western part of the country. Three projects were designed top-down, the other three in a bottom-up manner.

The first four cases are situated along the river Rhone in the southern Swiss canton of Valais. The primary impact of climate change in this region will be a rise in temperature and a change in precipitation patterns (Beniston 2004). Increased melting of glacier and snow cover and heavier rainfalls are expected to produce a considerable transformation of the runoff regime. In turn, higher sediment and debris transportation will magnify the consequences of more frequent natural disasters, including floods, landslides, mud flows, and soil erosion (Frei et al. 2007, Beniston 2004). In 1987, 1993 and 2000 the region's local communities experienced severe floods that caused costly damage to infrastructure and agricultural land. The canton, in collaboration with the federal government and municipalities, responded with a major integrated water management initiative (Third Rhone Correction, TRC) consisting of technical and socio-economic means to facilitate adaptation to future flood risk (Ingold et al. 2010). The TRC precipitated three parallel developments: the TRC Priority Measures Visp (PM), land reallocation (Integralmelioration) Visp-Baltschieder-Raron (IM VBR) and Brigerbad-Lalden-Visp (IM BLV), and the elaboration of a Regional Development Concept (RDC).

The first case consists of the Priority Measures Visp (PM Visp). It is a natural hazard protection project for the small industrial town of Visp. This town is traversed by the Rhone and acts as an important traffic corridor linking the country's northern and southern parts (Ingold et al. 2010). Land use in the periurban municipalities south and east of Visp (Lalden, Brigerbad and Visperterminen) is
characterized by riparian and hill-side agriculture. The aim of the PM Visp is to protect the region’s local communities from a hundred-year flood event with an estimated spatial impact of more than 1’000 ha and more than 2 billion Euro worth of damage. The undertaking includes three technical measures: widening the riverbed to increase runoff capacity in Baltschieder and Lalden; lowering the riverbed to increase water throughput capacity in Visp; and fortifying dams throughout the entire area. PM measures started in 2002 and construction began in 2009. The project is expected to be completed in 2013.

The land reallocation projects (IM VBR and IM BLV) are a complement to the PM designed to compensate land owners for the loss of agricultural surface required for widening the riverbed. Ordered by the canton, municipalities are responsible for ensuring that the land reform produces an equitable distribution of lands not affected by the river project. The reform beneficiaries are required to form a land management cooperative. IM negotiations started in 2008.

The three projects PM Visp, IM VBR and IM BLV are all three examples of top-down designed processes under the lead of or ordered by the canton.

The fourth case of interest here is a project for the elaboration of a Regional Development Concept (RDC). Although also located in the upper part of the canton of Valais, the RDC is concerned with a much larger area, ranging from the historical town Brig in the north to Salgesch in the south of the upper Valais (Ingold et al. 2010). RDC elaboration aims to define long-term regional development objectives regarding preemptive climate adaptation measures. Three working groups – nature, landscape and tourism; business and industry; and spatial planning, infrastructure and transport – involving more than forty state and non-state organizations worked on the development of the RDC for almost five years before priority measures and long-term objectives could be agreed on in 2006.

The last two cases are a regional natural park project (PJV) and a process concerning the demarcation of agricultural utility surfaces (Bullet) in the western part of Switzerland. Both projects are located on the high plateau of the Valley de Joux that lay on the border with France at an altitude of about 1000m. It stretches over approximately 35km (20km in Switzerland) from south-west to north-east. In the north and the south, the valley is defined by two mountain ranges. Due to its remote location, this region is still very rural with some signs of early industrial production. The valley is composed of three municipalities. Agriculture and forestry have a relatively large impact on the economy, but their share of employment is decreasing (Ingold et al. 2010). The industrial sector takes the largest share in employment with many firms specialized in watch-making and fine mechanics.

Regional predictions about the impact of climate change expect summers to become much drier and precipitation to shift into the autumn and spring seasons. Farmers will need to irrigate fields on a
regular base which may cause conflicts over resource usage since water is a scarce resource in the region already. Summering areas in higher altitudes will be particularly affected by dry seasons as they are very difficult to access and infrastructure (e.g. irrigation systems) is lacking.

The *Parc Jura Vaudois (PJV)* was founded in 1971 with the original aim of protecting the scenic beauty characteristic of the region. Today, the PJV is a candidate for the title of “regional nature park”*, a new federal instrument for regional promotion combined with socio-economic and nature protection goals (FOEN 2009). Its candidacy signifies a shift in the park’s objectives: in addition to the conservation of cultural heritage, other concerns such as soft tourism and the promotion of regional products have become important. The jurisdiction of Bullet (Bullet) lies in the same area, but the context is different: Bullet is not in the natural park’s area and effective resource management is highly dependent on the appropriate demarcation of agricultural utility surfaces, which allow for more intensive use of agricultural land than this is the case in summering and protected areas. The issue of climate change adaptation is in both cases just one of several concerns, although a central one: The conservation of the wooded-pasture landscape is a major issue in this region. Besides land-use changes, wooded-pastures are also highly sensitive to increases in temperature and changes in precipitation patterns. In a strategy different from that of the Bullet project regarding the demarcation of agricultural utility surfaces, the integrated management of the PJV should reconcile conflicts between resource use and nature protection that may arise or be fostered through climate change impacts.

The RDC, PJV and Bullet projects were all designed under the leadership of local actors and are thus *organized from the bottom up*.

For the definition of the key actors in the six case studies, we rely on the classical combination of decisional and reputational approaches. According to Knoke et al. (1996, 7), formal organizations, rather than individuals, stand in the foreground of today’s politics. Therefore, actors are defined in our research as organizations integrated into the policy design of the six resource projects. Following the decisional approach, actors formally involved in the decision-making of regional resource management policies are identified. This first list was completed with actors who were mentioned as very powerful by 2-5 interviewed experts in each region. In the end, we had a set of 38 actors for PM Visp, 26 and 27 respectively for IM VBR and IM BLV, a set of 39 actors for the PJV, and 19 and 35 respectively for Bullet and RDC. Each actor received a standardized questionnaire via regular mail. The response rate ranged between 65% and 75% for five of our cases, which is substantial for a postal survey. In the case of Bullet, however, only 6 out of the 19 surveys were returned.
The questionnaire was split into two parts: the first part concerned questions about the relational profile of every actor. To conduct a formal social network analysis (SNA), survey participants were asked to indicate information and collaboration relations they share with all identified actors of the studied project. More concretely, the following questions were asked:

- From the presented list of actors:
  - To whom did you give information about the content, process or schedule of the respective project within the period from XX to YY?
  - From whom did you receive information about the content, process or schedule of the respective project within the period from XX to YY?
  - With whom did you collaborate closely during the
    - Decision-making phase of the respective project within the period from XX to YY?
    and/or
    - Implementation phase of the respective project within the period from XX to YY?

Respondents were free to add other actors not included in the list of actors presented to them. If an additional actor was mentioned at least twice, the questionnaire was then also sent to this institution or organization. The two networks of giving and receiving information were matched together in one single network of directed information exchange. For the collaboration network, we took into consideration only the phase of decision-making and policy formulation, and not the implementation phase.

The second part of the survey consisted of a set of questions related to the content of the respective project. The different objectives and goals were identified for each project and actors could express their position towards the respective issue. Results from the second part were not taken into consideration for the research presented here.

6. Analysis

This analysis first compares the overall densities, the core/periphery structure and cliques within the information and collaboration networks of all six cases. This first step leads to the conclusion that information can, in fact, be defined as weak – and collaboration as strong -- ties. Furthermore, the role of local actors and actors participating in the core of both networks can be deduced. Finally, correlations between the two networks are assessed to investigate if information may lead to collaboration relations.
Comparison of densities

As the density depends on the number of nodes – in our case the number of actors present in the network – it only makes sense to compare densities of specific types of networks (e.g. information, collaboration) within a given network of actors or among networks with similar numbers of nodes. If the densities of the information networks are greater than those of the collaboration networks, this might be a first confirmation that information ties are of weak character and thus easier to establish.

Table 1 – Densities in information and collaboration networks

<table>
<thead>
<tr>
<th>Case (N)</th>
<th>Information</th>
<th>Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Density</td>
<td>Nr of ties</td>
</tr>
<tr>
<td>PM Visp (38)</td>
<td>23%</td>
<td>319</td>
</tr>
<tr>
<td>IM VBR (26)</td>
<td>21%</td>
<td>135</td>
</tr>
<tr>
<td>IM BLV (27)</td>
<td>17%</td>
<td>118</td>
</tr>
<tr>
<td>PJV (39)</td>
<td>21%</td>
<td>318</td>
</tr>
<tr>
<td>Bullet (19)</td>
<td>9%</td>
<td>31</td>
</tr>
<tr>
<td>RDC (35)</td>
<td>22%</td>
<td>263</td>
</tr>
</tbody>
</table>

As illustrated in Table 1, densities are much greater and the number of ties present higher in the information networks than in the collaboration networks. This difference is more remarkable for the top-down than for the bottom-up designed processes.

Core/Periphery structure

The applied categorical core/periphery measure in UCINET (Hanneman&Riddle, 2005) is based on a fit function that operationalizes a correlation between the effective and permuted data matrix and the ideal-typical core/periphery function introduced above in section 4.
Table 2 – Core/periphery structure in information and collaboration networks

<table>
<thead>
<tr>
<th>Case (N)</th>
<th>Information</th>
<th>Collaboration</th>
<th>Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of actors</td>
<td>% of core that</td>
<td>% of actors</td>
</tr>
<tr>
<td></td>
<td>in core</td>
<td>is local actors</td>
<td>in core</td>
</tr>
<tr>
<td>PM Visp (38)</td>
<td>40%</td>
<td>73%</td>
<td>42%</td>
</tr>
<tr>
<td>IM VBR (26)</td>
<td>50%</td>
<td>46%</td>
<td>58%</td>
</tr>
<tr>
<td>IM BLV (27)</td>
<td>59%</td>
<td>38%</td>
<td>48%</td>
</tr>
<tr>
<td>PJV (39)</td>
<td>26%</td>
<td>20%</td>
<td>36%</td>
</tr>
<tr>
<td>Bullet (19)</td>
<td>47%</td>
<td>11%</td>
<td>42%</td>
</tr>
<tr>
<td>RDC (35)</td>
<td>54%</td>
<td>56%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Comparing the sizes of cores (% of actors from the network present in the core and thus absent in the periphery), there is a tendency for cores of collaboration networks being larger than in the corresponding information networks. Results for the Melioration BLV and the case of Bullet, however, are to the contrary. Still, our assumption is largely confirmed that cores tend to be bigger in collaboration networks; the ratio between core and periphery is more equilibrated within information networks.

In the third and fifth column, one sees the percentage of the respective cores that are local actors. In the PM Visp, for instance, 73% and 69% of the information and collaboration cores, respectively, are represented by local actors. Surprisingly, local actors are more strongly represented (from one third to almost three-fourths) in the three top down processes (PM Visp, IM VBR and BLV) than in the bottom-up-designed ones. One exception is the Regional Development Concept (RDC), for which 56% and 68% of all actors in the core represent the local level.

It is also interesting to observe the overlap in cores: do actors in the core of the information network also participate in the core of the collaboration network? If so, this would be: 1) another indication that information may lead to collaboration, and 2) that there exist crucial actors who manage to establish sustainable relationships with actors. The result is clear: a huge overlap of actors participating in the cores of information and of collaboration networks exists. Again, this result is stronger for the top-down than for the bottom-up designed processes.

Simmelian tie approach

A tie between actor i and actor j is Simmelian if and only if both i and j are tied to each other and there is at least one third node to which both i and j are reciprocally tied to (Tortoriello & Krackhardt 2008). This definition corresponds to the concept of a clique, which is a maximally complete
subgraph (Wasserman & Faust 1994) where actors have all possible ties present amongst themselves (Hanneman & Riddle 2005). We thus investigate how many actors are present in a given clique (of minimum size of three or more actors) and therefore share a co-clique relationship.

Table 3 – Densities in information and collaboration networks

<table>
<thead>
<tr>
<th>Case (N)</th>
<th>Information</th>
<th>Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of actors in cliques</td>
<td>% of actors in cliques</td>
</tr>
<tr>
<td>PM Visp (38)</td>
<td>68%</td>
<td>23%</td>
</tr>
<tr>
<td>IM VBR (26)</td>
<td>73%</td>
<td>0%</td>
</tr>
<tr>
<td>IM BLV (27)</td>
<td>74%</td>
<td>0%</td>
</tr>
<tr>
<td>PJV (39)</td>
<td>72%</td>
<td>23%</td>
</tr>
<tr>
<td>Bullet (19)</td>
<td>32%</td>
<td>0%</td>
</tr>
<tr>
<td>RDC (35)</td>
<td>80%</td>
<td>34%</td>
</tr>
</tbody>
</table>

As expected, it is easier to create triads within the network of weak relations; with the exception of Bullet, more than two-thirds of all actors in the information networks are involved in cliques of minimal size of three actors. A very different picture is presented in collaboration networks: three projects do not display any clique structure at all. Thus no or very few dense sub-graphs exist in collaboration networks, and therefore trust-building and the enhancement of strong relations has not yet been transmitted from the information to the collaboration network.

**Correlation Results**

Observations in Social Network data are per definition interrelated. The Quadratic Assignment Procedure, applied here to assess the correlation of the two networks, uses permutations and is based on the concept of identifying the value of the measure of association when there really is no systematic connection between the two relations.

One knows from the previous analysis that densities and clique-co-memberships are in all cases higher in the information than the collaboration network. If one can detect a correlation between the two networks, this would support the argument that the establishment of weak relations (such as information) has the potential, and can be seen as a first step for the creation of stronger ties (such as collaboration).
Table 4- Correlations between information and collaboration

<table>
<thead>
<tr>
<th>Case (N)</th>
<th>Value</th>
<th>Average</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM Visp (38)</td>
<td>.83</td>
<td>.70</td>
<td>.001</td>
</tr>
<tr>
<td>IM VBR (26)</td>
<td>.85</td>
<td>.85</td>
<td>.01</td>
</tr>
<tr>
<td>IM BLV (27)</td>
<td>.87</td>
<td>.78</td>
<td>.01</td>
</tr>
<tr>
<td>PJV (39)</td>
<td>.85</td>
<td>.72</td>
<td>.001</td>
</tr>
<tr>
<td>Bullet (19)</td>
<td>.94</td>
<td>.87</td>
<td>.001</td>
</tr>
<tr>
<td>RDC (35)</td>
<td>.84</td>
<td>.67</td>
<td>.001</td>
</tr>
</tbody>
</table>

Table 2 shows the results of the Simple Matching correlation, a reasonable measure for binary data, as in this case (0 when the relation is absent, 1 when it is present). The values indicate for all six cases a strong correlation between information and collaboration relations. All results are significant within the 99% and 90% confidence interval for PM Visp, PJV, Bullet, and RDC, and for IM VBR and IM BLV, respectively. The average shows the value of the measure of association across a large number of trials in which the rows and columns of the two matrices have been randomly permuted. That is, what would the correlation (or other measure) be, on the average, if we matched random actors? Our observed values vary only slightly from a random result.

7. Discussion

Overall, densities are stronger and the presence of cliques greater in the information compared to the collaboration network, in agreement with our preliminary assumptions. This is a strong indicator that information, as a one-way relation, is easier to establish than collaboration. Stated differently, collaboration, as a reciprocated exchange, appears to be more difficult to achieve than information exchange in resource management. This leads us to the assumption that collaboration is a strong relationship that enhances trust among actors and thus has the potential to create exchanges that last longer than the duration of the project in which they were built. This assumption is further confirmed by the core/periphery analysis where cores are – with two exceptions –bigger in the collaboration network: collaboration thus seems to be a more integrative type of relationship that structures a network around a large core and a rather small periphery. One-way relations such as information make it possible for actors to intervene only sporadically, to relate only to one or a few actors within the core and to not engage in the larger participatory process.

But does information exchange lead to collaboration? Would information thus be a first step in the establishment of stronger and more sustainable ties, such as collaboration? Based on the correlations between information and collaboration ties, the first hypothesis is confirmed. In all six
cases, there is a strong relationship between the two types of relations. But one limitation has to be mentioned at this stage: even though specific results differ for information and collaboration in the analysis presented here for the six cases, information and collaboration can be understood as very similar concepts, which could lead to the strong correlation observed as well as to the huge overlap of actors present in the information as well as the collaboration cores. In this analysis, we carefully defined and explained the difference between information (a directed tie) and collaboration (a mutual relationship) to the actors involved in our survey. Nevertheless, survey participants may still misunderstand the distinction between concepts, or may mistakenly identify the presence of one type of network for the other. If this is the case, it is the similar characteristics of information and collaboration ties, rather than one being a precondition for the other, that explain the correlations and core overlap.

Another limitation of this research regards the implicit direction we assume: our assumption states that information is a pre-condition for collaboration. To test this assumption more carefully, one would be obliged to do a two-step analysis, meaning that in period 1 only the presence of information would be observed, and in period 2 only the presence of collaboration. Due to resource limitations, however, we simultaneously assessed the two relational types. Thus, correlations between relations could theoretically also be interpreted the other way around (collaboration leads to information), or as evidence that the types are mutually supportive. Conceptually and empirically, however, we confirmed that information is a weak relationship that is easy to establish, and collaboration is a strong tie that demands mutual engagement, which leads us to the conclusion that information networks have a tendency to be a pre-condition for collaboration networks.

The analysis presented here demonstrated that we cannot clearly differentiate between structural patterns of bottom up- and top-down-designed processes. The second hypothesis is thus not confirmed. Even though the differences between densities of information and collaboration networks are smaller for the three bottom-up-designed networks – what might have been a first indication that in those processes information leads more easily to collaboration -- the correlation analysis and cores’ overlap do not bear this clear pattern. Furthermore, local actors are surprisingly not as strongly represented in the cores of bottom-up-designed processes as in top-down-structured ones. One explanation for this could be that in order to implement short-term responses effectively, even in top-down processes, it is important to integrate local actors, which is why they are well-represented in the cores of those three case studies. Still, it is surprising that in the three bottom-up projects, cores are dominated by actors not regionally located in the area of concern.

Overall, the overlap of cores is remarkable: actors participating in the information core also tend to participate in the core of the collaboration network. This is another indication of how strongly these
two relations correlate: being well-informed seems to facilitate the establishment of mutual relations with the same group of actors. For the design of adaptation and natural resource management projects, this does not have only positive implications: stakeholders that are weakly-related to the core actors of the project through one-way information relations have difficulty integrating into the concrete policy design and implementation collaborative processes. They tend to give information or be informed - as is the case in traditional consultation procedures -, but they usually have a weak impact on the concrete policy formulation process.

8. Conclusions
The goal of this research was to investigate how local communities adapt to climate change. We argued that the establishment of social capital is an important factor of successful climate change adaptation. The aim was not to identify factors that lead to social capital creation but rather to assess what structural pre-conditions may lead to certain network structures (such as mutual collaboration that may have the potential to last beyond the duration of the given project) that can be activated in situations where short-term reaction and long-term adaptation to climate change are needed. We conducted a formal network analysis using a relational approach.

We were interested in the establishment of strong ties that may serve as a proxy for social capital creation. Based on the assumption that the quality of ties matters, we asked if information exchange (defined as a directed and weak tie) leads to collaboration (defined as a mutual and strong relationship). We analyzed six case studies in Swiss mountain regions: three climate change adaptation projects designed in a top-down manner; and three resource management projects designed in a bottom-up fashion.

This research has provides evidence that information correlates with collaboration and that there is a tendency for weak ties to be a pre-condition for the establishment of stronger relations among actors involved in climate change adaptation and resource management processes. Yet there is still no guarantee that a particular type of one-way relations lead to mutual relations of a given type. As shown in the clique analysis (Table 3), sub-groups of densely related actors in the information network are not reproduced within the collaboration network. This is an important finding: such sub-groups of densely related actors within a network of strong ties (in this case, of collaboration) would have been an important indicator of sustainable network structures, trust-building and, ultimately, social capital enhancement. Although there is a tendency for information to lead to collaboration, we can thus still not conclude that weak ties influence the creation of more-sustainable network structures. Therefore, further research is needed; one major shortcoming of the
analysis presented here was that it only concerns one period of study and does not assess longitudinal data.

It would be interesting for further research to observe the structural patterns over time for the same case studies. This would allow a more rigorous confirmation of the hypothesis that information exchange leads to collaboration. Furthermore, one could then more carefully assess if similar network patterns (such as clique co-membership or core/periphery structures) are replicated from one network to the other in the long run.
Acknowledgments

Data for this research was gathered between 2009 and 2011 within the framework of the following project running at the Swiss Federal Institute for Technology (ETH Zurich): “Sustainable Land-Use Practices in Mountain Regions: Integrative Analysis of Ecosystem Dynamics under Global Change, Socio-economic impacts and Policy implications” (MOUNTLAND), supported by the Competence Center Environment and Sustainability.
Bibliography


Ingold, K., Balsiger, J., Hirschi, Ch., 2010. Climate Change in Mountain Regions: How Local Communities Adapt to Extreme Events. Local Environment 15 (7):651-61.


OCCC, 2008. Das Klima ändert sich – was nun?. Der neue UN Klimabericht (IPCCC 2007) und die wichtigsten Ergebnisse aus Sicht der Schweiz. Bern: OCCC.


