Institutional adaptation to climate change: Flood responses at the municipal level in Norway

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Abstract

This article examines the role institutions play in climate adaptation in Norway. Empirical findings from an examination of responses to the 1995 floods in two municipalities in the Glomma-Lågen river basin, Eastern Norway, are presented. We identify institutional factors that affect the adaptation potential at the local level, and factors that serve to constrain or facilitate the realisation of this potential. The study suggests that institutions provide important insights for understanding local responses to climate change as well as for designing future strategies for adaptation.

Keywords (max six): Climate change, Adaptation, Floods, Institutions, Norway

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1 Introduction

Adaptation is increasingly seen as a necessary complement to greenhouse gas mitigation measures (Smit et al., 2001). Human-induced climate change is likely to present new, and to a large extent, unpredictable challenges to societies. This is of particular concern at a local level – first because scenario uncertainties are highest here, but also because studies of past climate-induced natural disasters (Quarantelli, 1987; Blaikie et al., 1994; Morrow, 1999), as well as long term climate change (Liverman, 2002; O'Brien et al. in press) show that vulnerability and its causes are location-specific. There is increasing attention paid to the need for a place-based understanding of vulnerability, as a large proportion of decisions regarding climate-induced hazards are local (Cutter, 1993; 2003). However, local decisions are shaped by interactions at the local level as well as interactions with structures at higher geographical scales that may mandate, encourage and inform actions (Wilbanks and Kates, 1999).

Norway displays characteristics that make it instructive in a European context. Its assumed adaptive capacity is high, based on indicators such as economic resources, technology, information and skills, and infrastructure (O'Brien et al., in press). At the same time, high adaptive capacity does not automatically lead to successful adaptation (Yohe and Tol, 2002; Smit et al., 2001; Burton et al., 2002). Furthermore, there are significant geographic differences within Norway in terms of adaptation context as well as records of failures in adaptation (Lisø et al., 2003). An emerging challenge is therefore identifying how resources underpinning adaptive capacity can be translated into actions that reduce the societal vulnerability to climate and other stressors.

In this article, we analyse factors that constrain or facilitate the ability of local level institutions in Norway to carry out adaptation measures. Specifically, we examine measures taken in Skedsmo and Ringebu municipalities after the 1995 floods in Southeastern Norway. The 1995 floods were in some areas the largest in 200 years. They led to evacuation of 7000 people and caused damages equivalent to NOK 1.8 billion. We examine how interactions between institutions at municipal level and other geographical and managerial levels, particularly the national level, shaped the measures that were carried out. We focus on how social learning[1] and conflicts of interests constrained or facilitated the institutional capacity to carry out adaptation measures. We look at the institutional factors that shaped decisions regarding the use of flood-prone areas, and in particular how institutional interaction across scales influenced decision outcomes.

An increasing body of literature, including work focusing on the role of social capital in vulnerability and resilience (Adger, 2000b), suggests that institutional factors are crucial in determining adaptation (Adger, 2000a; Bakker, 1999; The Heinz Center, 2002; Tol et al., 2003). Institutions affect the social distribution of vulnerability, as well as determine the management of climate-sensitive aspects of society and, in turn, the capacity to adapt successfully. The focus of this study is institutions connected to the formal municipal administration in Norway and their capacity to make decisions that reduce local vulnerability to future floods.

Findings in Ringebu and Skedsmo municipalities suggest that the current institutional set-up favours technical solutions to flood management, and that this bias has implications for vulnerability to future climate change. A more comprehensive approach incorporating social and environmental aspects is therefore

called for. We suggest that flexibility and a high capacity for institutionalizing past experiences through learning might facilitate adaptation at the local level under changing climatic conditions.

2 Framework for institutional analysis

2.1 Study design

Experiences from past climatic events may provide useful insights into the constraints and barriers to adaptation to future climate change, especially since climatic events have been found to trigger significant institutional changes (Miller et al., 1997). A local-level approach to historical extreme events provides empirical data that may hold important lessons for the future (Smit et al., 2001). Temporal analogues, described by Glantz (1989) and other authors, involve investigating the effects of past climatic events, emphasising processes of response more than the precise nature of the event itself. Applying an analogue approach, we analyse specific institutional aspects of responses to the 1995 floods in two municipalities in the Glomma-Lågen river basin, Southeastern Norway.

A case study approach was chosen because of its suitability in explaining current phenomena where one has little control over the events, and where one seeks answers to questions of how and why (Yin, 1994). It has been argued that human-environmental interaction in global change can be most effectively studied by focusing on particular events (Vayda and Walters, 1999). The complexity of relations among the social, environmental and economic processes that drive global change, as well as consequences of such change, can best be understood by 'careful locality-specific research'. Although case-specific research can be difficult to

generalize, comparative studies using case studies as 'natural experiments' can facilitate theory-building (Wilbanks and Kates, 1999). By comparing two municipalities, Skedsmo and Ringebu, constraints and barriers to local adaptation that are unique to the local context and constraints borne out from institutional structures and processes can be distinguished.

Wilbanks (2002) argues that climate change studies should pay attention to processes operating at several scales. A focus on a single geographical scale can frame an investigation too narrowly on issues, processes, data and theories associated with that scale. We define our investigation to the scale of decision-making unit as recommended by Cash and Moser (2000), but incorporate information from multiple scales by examining the interactions with other decision-making institutions that affect policy outcome.

The Glomma and Lågen river basin, located in the Southeastern part of Norway (See Figure 1), has been exposed to a number of large floods over the past centuries. Major floods occurred in 1789 ("Storofsen"), 1860, 1927, 1967 and 1995 (Eikenæs, Njøs et al. 2000). The severity of the floods of 1995 was due partly to high snow accumulation levels in the spring, but more importantly the late onset of the snow melting (end of May) combined with rapid temperature increases and sudden heavy rainfall (Eikenæs et al., 2000; Roald, 2002). The resulting sharp increase in water levels triggered widespread soil erosion and river sediment transport, in turn causing considerable damages to roads and railways, buildings, technical installations, and farmland (Brænne, 1995; Hindar et al., 1996; NIVA, 1996; NOU, 1996; Øygarden et al., 1996; Eikenæs et al., 2000). The floods had an overall return period of 100-200 years; in parts of the river basin it was the biggest since the great floods of 1789 (Skurdal et al., 2000). One person was killed and 7000

had to be evacuated from their homes (Lundquist et al., 1996). Costs of flood damages were estimated at a total of NOK 1.8 billion, of which NOK 1 billion was covered by private insurance and NOK 0.8 billion by government funds (NOU, 1996).

[FIGURE 1 HERE]

Skedsmo and Ringebu municipalities (see Figure 1) were selected as study sites because they were both severely, though differently, affected by the 1995 floods, and have both been required to follow new government legislation implemented as a result of the floods. Climate change is particularly pertinent to these two municipalities because not only do they face the risk of submerging from flooding in major rivers, they also face risks of sudden increases in water flow in smaller, local rivers and urban areas. Skedsmo also faces a potentially increased instability of marine clay sediments. The demographic, socio-economic and geographic differences between the municipalities provide a valuable context for analysis, Skedsmo being a more populous and urbanized municipality than Ringebu.

We conducted semi-structured interviews that included open-ended questions regarding responses and the management of flood-prone areas in the aftermath of the 1995 floods. Fifteen officials were interviewed in Ringebu and Skedsmo municipalities, including heads of the technical/planning, environmental and agricultural departments involved in area planning and emergency management. A further five interviews were conducted with representatives of other interest groups (fishing association, farmers' union, environmental information foundation, planning consultancy company, political party). We supplemented with interviews with

regional and national level officials in water resources- and emergency management institutions. Secondary information regarding the 1995 floods was reviewed, together with recent literature regarding institutions, regulations and adaptation to climate change, presented in Næss (forthcoming).

2.1.1 Ringebu

Ringebu is located in the Gudbrandsdal valley, Oppland County. The municipality has 4644 inhabitants (as of 1 January 2003) and covers an area of 1250 km^2, 60% of which is above 900 m.a.s.l.[2] The population has decreased slightly over the past decade. The largest recorded floods in Ringebu are the great floods of 1789 ("*Stor-Ofsen*"). In normal years, there are two largely unproblematic floods in Ringebu, following snow melting in the catchments of, respectively, the rivers of Lågen and Otta. A number of flood defences have been built along the Lågen River to straighten and stabilize the river, thus preventing damage to properties and agricultural areas. A new highway has been built on the river plain in the Southern part of the municipality near Fåvang, also acting as a flood dike.

2.1.2 Skedsmo

Skedsmo Municipality is situated northeast of Oslo, in Akershus County. It covers 77 km^2 and has 40 676 inhabitants (as of 1 January 2003), 95% of whom live in urban or semi-urban areas. The population is steadily increasing and the municipal administration estimates a need for 3-500 new housing units per year in the near future. Floods in Skedsmo have traditionally been governed by its proximity to Lake Øyeren and the three main rivers discharging into it, Nitelva, Leira and Glomma. Apart from the great flood of 1789, major flood years include 1860, 1863, 1867,

1890, 1895, 1910, 1916, 1927, 1934, 1966, 1967 and 1995. An important bottleneck has been the outlet at Mørkfoss. The width of the riverbed at Mørkfoss was widened in 1860 and after the floods in 1967. Skedsmo also experienced rain-induced floods in 1997 and 2000.

2.2 Research questions

Institutions are systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles (Young, 1998). They arise in all areas of human endeavour and can be either formal or informal.

In the context of this study, however, we focus on formal institutions at the municipal level taking part in decision making processes concerning use of flood prone areas, and how they interact with institutions at county and national level. We discuss the way decisions are shaped by the interplay between institutions, and furthermore how new experiences, information and social learning, as well as power-constellations and interest conflicts affect the potential for adaptation for local-level institutions. Key roles of institutions at the national and municipal level are described in more detail in Table 1. Our investigation focuses on the institutions relevant to management of flood prone areas, in particular area planning and water resources management institutions.

[TABLE 1 HERE]

A better understanding of how institutions shape flood management may be useful in a climate change perspective for several reasons. Climate change may put

new demands on existing institutions, either through aggravating current flood problems or through creating new situations and new types of problems, floods in different parts of the year, and new types of floods (Miller et al., 1997; Tol et al., 2003; Brown and Damery, 2002). The *ability* (both economically and logistically) of a local community to carry out measures to reduce the risk of negative effects from future similar climatic-induced events may be closely related to the *capacity of municipal institutions* to prepare for climate change in future. In other words, the degree to which municipal institutions are prepared and flexible in terms of handling the unexpected might be a determining factor for the municipality's responsive capacity.

[FIGURE 2 HERE]

Figure 2 illustrates that decisions at the municipal level aimed at flood management may be either made directly in response to a severe flood event (pathway "A" in the figure), or made as a response to national level decisions that affect the framework of decision making at the municipal level (pathway "B"). The arrows indicate flows of information and influence: first that floods trigger responses, and further that there exist, through formal and informal channels, two-way information and influence pathways among institutions at different levels.[3]

The overriding question of interest in this study is to what degree municipal institutions are appropriate instances for responding to climate change adaptation issues such as flooding. To address this general question, we have formulated three more specific research questions.

First, the interaction between different interest groups in the municipality, as well as potential conflicts of interests both between actors within the municipal level and between the municipal and regional and national levels may constitute barriers and constraints to adaptation. For instance, there may be a conflict between economic and environmental interests regarding the shaping of a particular adaptation measure. Differences in interests between actors in the local community may lead to conflict over what kind of actions should take priority or how to shape a particular adaptation measure. The objectives of a measure serve different interest groups in the municipality. For example, if flood protection is built around vital agricultural land, but at the same time is used as the main road through the municipality, uncertainty arises as to the main objective of the flood wall: protection of agricultural land, or providing a new and better road? Also, differences in interests between municipal, county and national institutions may affect decision-making about local area planning, for instance where county or national institutions have power in decision-making processes (pathway B in Figure 2) that override the municipal administration. Thus the first research question is to what degree conflicts of interest have constrained the potential for adaptation and shaped the types of measures that have been enacted.

Second, municipal institutions represent a potential for storing and passing on relevant knowledge from actions taken during previous extreme events (Pathway A in Figure 2). This institutionalisation of social learning could potentially alleviate the transition to a changed flood pattern resulting from climate change. In particular, specialized institutionalised knowledge about the local context could be valuable. However, social learning may also be a slow process, where established organizations and actors in the decision-making process, for instance on local area

planning, may resist changes in structures and practices. Such resistance to change may affect local ability to adapt to climate change. An institutional set-up appropriate to the present climate may not be effective when faced with changing climatic conditions unless it exhibits flexibility and the ability to institutionalise new knowledge. While specialized knowledge held by specific experienced individuals may be instrumental in achieving successful adaptation, the real question is to what degree this knowledge can be successfully transferred to the institution – that is, to what degree the society as a whole can "learn" from the experiences of its individuals (Olsson and Folke 2001). Thus our second research question is to what degree social learning has facilitated adaptation and shaped the types of measures that have been enacted.

Third, learning from a flood event also takes place indirectly through national level responses and generation of information (Pathway B in Figure 2). In the aftermath of the 1995 floods, a government commission on flood protection (*Flomtiltaksutvalget)* was established to look into experiences from the floods and what could be done to prevent similar damages in the future (White Paper no. 37, 1995-96 and no. 42, 1996-1997; NOU, 1996). The HYDRA research project (1997-2000) was initiated to improve the knowledge base on floods and give recommendations for policy measures to prevent and mitigate future floods. Several assessments of flood impacts on agricultural lands, technical installations, water quality, socio-economic systems, and ecosystems were carried out (Brænne, 1995; Hindar et al., 1996; NIVA, 1996; NOU, 1996; Øygarden et al., 1996; Eikenæs et al., 2000). From 1998, flood zone maps were developed by the Norwegian Water Resources and Energy Administration (NVE) and were intended for use by municipalities to identify areas of high flood risk and needs for flood protection

measures. New standards for building in flood-prone areas, including regulations on area planning in risky areas and guidelines on the use of flood-prone areas were developed (NVE, 1999; Ministry of Environment and Ministry of Municipal and Local Governments, 1997). Early warning systems were also strengthened, especially the risk and vulnerability analysis in municipalities. However, the receptiveness and incorporation of national responses to a flood, nationally generated information and guidelines, as well as regulations at the local level (Pathway B in Figure 2) may not always be smooth, nor may local experiences from a flood feed back effectively into national level knowledge systems. Thus the third main research question is how the interaction across scales affected adaptation and shaped the types of measures enacted at the municipal level.

3 Case study: the 1995 flood and responses

3.1 The 1995 floods in Ringebu and Skedsmo

The 1995 floods demonstrated that both Ringebu and Skedsmo are vulnerable to climatic extremes, in terms of both economic and social impacts. In Ringebu, the two main population centres are located on old river deltas of tributaries to Lågen River, Tromsa and Våla. These tributaries caused the main economic damages in Ringebu during the 1995 floods as they carried large amounts of stone and gravel from the mountains, depositing them in the lowlands. Concern over damage to the water supply pumps (and hence pollution of the drinking water) prompted a temporary closure of the drinking water supply to private homes. Other economic damages included loss of agricultural harvest on the floodplain, damages to forest

feeder roads and bridges, and damages to buildings at the Winter Olympic arena at Kvitfjell. Total flood damage costs in Ringebu were estimated to NOK 21 million. The main road through the valley (E6) was submerged. The railroad was closed, and the township of Ringebu was effectively isolated for a period during the flood peak. Similarly, large areas of Skedsmo municipality, including parts of the town, Lillestrøm, were flooded in 1995. A large share of the population in Lillestrøm had to be evacuated during the floods.

The emergency responses in both municipalities demonstrated a high degree of coordination between institutions at different levels, including relevant offices in the municipality administration, the regional waterworks, fire departments, the Civil Defence authorities, as well as NVE and the county administration. Following rapid increases in water levels and warnings from the Glomma and Laagen Waterworks Cooperative (GLB) and NVE on an impending major flood, each municipality established an emergency council, formally led by the Mayor.

Emergency preparedness limited some of the damages in Skedsmo. The flood warning reached the municipality on 25 May 1995, and gave the authorities time to prepare. Furthermore, a flood emergency plan set up after the flood in 1967 had been reviewed as a matter of routine during late April/early May 1995. Measures implemented after the flood warning arrived included closing manholes and drains, the latter to avoid clogging of the drainage system given its limited ability to deal with large and sudden inflows of rainwater. A (temporary) flood dike was built along the river Leira, and a temporary flood protection wall was set up through the township of Lillestrøm, where a large share of the population had to be evacuated during the floods.

Water levels in Lake Øyeren peaked on 8 June 1995 at 2.22 metres below the

recorded peak water levels in 1967. It is estimated that peak levels were lowered by 2 metres due to regulations upstream from Lake Øyeren in the Glomma and Lågen rivers and another 2 metres due to greater capacity at the outlet out of Lake Øyeren, i.e. a total of 4 metres.

3.2 Municipal responses to the 1995 floods

3.2.1 The impact of conflict of interests on policy outcome and climate adaptation

We found that in both municipalities, technical measures were a dominant decision outcome in vulnerability reduction, often favouring economic interests at the expense of environmental interests. The technical bias was particularly strong where there was consensus between municipal, county, and national level institutions. In both municipalities, there was general agreement between different departments within the municipality that several technical improvements had to be made to infrastructure in order to prevent similar future impacts. Many of these improvements corresponded to the information and priorities outlined by national level assessments of flood impacts and the government flood commission (NOU, 1996). Following the floods, technical installations for drinking water, electrical supply, bridges, and roads in Ringebu were repaired and elevated to above the peak water level to ensure safety during similar flood events in the future. A map showing peak water levels during the flood[4] was used by the municipal planning office.

Skedsmo demonstrated a general consensus for major, expensive technical measures in response to the 1995 floods. A permanent flood dike was built around Lillestrøm township after the municipal government made a unanimous decision in favour of it on 30 August 1995, less than two weeks before the local elections. The flood dike was built at 106.5 metres above sea level, compared to the standard level

of 101.6, at a total cost of NOK 74.3 million.[5] The municipality and NVE both contributed 27 million, the national Ministry of Defence contributed 1.6 million, and Dyno industries (local firm) contributed NOK 0.5 million. Fifteen pumping stations were constructed in connection with the dikes. A new emergency plan was prepared in light of the new measures. It was estimated that Lillestrøm would now be secure against 300-year floods (the 1995 floods peaked at a 200-year flood level). A flood dike was also constructed near the village of Leirsund, where NVE covered all the costs.

In Ringebu, most of the measures to reduce vulnerability after the 1995 floods were technical in nature, some leading to conflicts with fishing and environmental interests. National institutions involved in environmental and resource management interacted with the municipal Technical Department in decision making regarding flood responses. Fishing and environmental interests were critical of flood defence measures in the aftermath of the 1995 floods. Gravel and stone were removed from the tributaries, particularly near the river mouths where they had built up during the floods. A fishing association for the Lågen River did not oppose the removal of sedimented material per se, but critisised the way the sediment removal was implemented after the floods. Out of consideration for fish spawning grounds, the County Environment Administration limited the amount of gravel and stone proposed removed by the municipal Technical Department. The fishing association nevertheless argued that removal of gravel and sediments after the floods caused more damage to river fish stocks than the flood itself.

Conflicts of interest also arose in Skedsmo between environment conservation on one hand and construction work on the other. The municipality encompasses areas rich in biodiversity (Leira River and riverine landscape). These

areas were affected by construction work during the 1990s in connection with a new main airport for Oslo (Gardermoen), including an airport railway line. Interviewees said the work had impacted on the annual river flood cycle, in that floods arrive earlier and peak sooner than before. The areas along the river are also attractive for developers. A golf course has been planned, but not yet approved for construction. Similarly, conservation of natural ravine landscapes conflicts with housing developments and forest management. Several residential areas in Skedsmo were constructed in a ravine landscape and have proved susceptible to landslide during extreme rain events. Measures to protect houses have been made. Feiring Bruk, a local construction company, made an agreement with the municipality to fill in the ravines and in return get the proceeds from sales of properties they have filled in. Levelling of the ravine landscape was earlier supported by the government. Furthermore, forest owners wish to level ravine areas to increase productivity, which is in conflict with biodiversity conservation. Some areas have already been filled in. The municipal environmental officer advocated a stronger conservation category for the Leira River to prevent loss of the environmentally valuable ravine landscape.

3.2.2 The role of social learning in facilitating policy formation and climate adaptation

Flood responses in 1995 and incorporation of lessons learnt afterwards relied largely on a few individuals' in-depth knowledge and experience. This was particularly evident in Ringebu, but also seemed to be the case in Skedsmo. Municipal institutions deemed such knowledge critical for vulnerability reduction. At the same time, there appeared to have been relatively little focus on formalising routines, including handover of vital knowledge of key persons to new staff.

There were relatively few changes in formal routines for emergency

management in Ringebu following the flood, for example. Interviewees raised concerns that responses during floods were arbitrarily organised, lacking in coordination and teamwork, with ad hoc and unclear allocation of responsibilities. A recent rehearsal of emergency routines revealed many of the same shortcomings as in 1995. Similarly, there appeared to be few if any *formal* changes in planning routines in the municipality following the floods. The municipal master plan has not been updated since 1993. While the map showing flood levels in 1995 was reported to be in use during the first years following the floods, it did not appear to be in active use today. With respect to flood defences, some interviewees expressed concerns that sedimentation patterns had changed over the last few years, and that this might be a result of technical interventions since 1995.

A dominant feature in the flood responses in the two municipalities was a weak interplay between municipal, county, and national levels in terms of information flow and learning. Interviewees in Ringebu, for example, expressed scepticism towards NVE and other national depositories of information, describing it as "too theoretical" and not showing enough interest in the concerns of the municipality. While flood zone maps were considered useful, the municipal administration focused less attention on flood warnings issued by NVE, as they were deemed too general and often regarding events that were very small in the Ringebu context as well as sometimes being issued too late. Emergency preparedness involves policies and structures to avoid and mitigate risks for natural hazards such as floods. The main instrument is formal laws and the main state institution is the Directorate for Civil Protection and Emergency Planning (DSB), which is under the authority of the Ministry of Justice and the Police. DSB has regional and local offices which coordinate follow-up down to the municipality level. The

collaboration with county and civil defence authorities appeared better with regard to emergency management, especially with the latter in a coordination and information role.

Interplay with national institutions in terms of information flow and incorporating learning appears to have taken place to a larger extent in Skedsmo than in Ringebu, both in terms of learning from the floods and improvement of emergency routines. As a result of the higher levels of interaction and agreement with national level institutions, NVE considers Skedsmo a good example of how municipalities should respond.

3.2.3 The effect of institutional interaction across levels on policy formation and climate adaptation

While institutional consensus across scales, particularly in the immediate aftermath of the floods, in some cases contributed to the observed technical bias in vulnerability reduction, there were also cases of diverging interests in municipal decision making. Decisions in Ringebu regarding construction in risk-prone areas were reached as compromises between economic interests (represented by municipal institutions), and the priority of minimising future risk (represented in municipal and national level institutions). In general, new construction was not allowed in areas that were flooded in 1995. An exception was a gasoline station on the floodplains, planned before the floods. Construction went ahead on the condition that the ground was elevated to above the peak flood level in 1995, but concerns regarding safety have been raised by NVE.[6]

Norwegian municipalities have the main responsibility for area planning according to the Planning and Building Act of 1985. In case of disputes plans in some cases have to be formally approved by the Ministry of the Environment. NVE is responsible for channelling support for building of flood defence structures, as well as giving advice on flood vulnerability. “The Guidelines for Building in Flood

Prone Areas," published by NVE, outline responsibilities of different actors. While in some cases construction plans in flood prone areas have been stopped by national level institutions, these institutions did not use their veto powers in the decision-making process regarding the gasoline station in Ringebu, an example of economic interests influencing flood-related decisions.

A case where a national institution did use its veto powers in decision making is the Ringebu municipal plan from 2000 to eradicate mosquitoes through draining and drying out wetland areas along the Lågen River. The municipality cited public health concerns as the main reason for the plan, but also benefits of making available more areas for agriculture and infrastructure. The County Governor opposed the plan, as did the national Directorate for Nature Management, arguing that the plan would lead to loss of biodiversity while pointing to uncertainty surrounding the effectiveness of the plan. The issue went to the Ministry of the Environment for a final decision. In August 2001, while on a visit during her election campaign, the Minister of the Environment promised support to the municipality, and finally approved the plan in October 2001.

The interaction between economic interests, municipal technical considerations, and national level institutions also shaped decisions about area use in Skedsmo after 1995. Municipal plans about building a shopping centre in an area that was submerged by 1.3 meters during the 1995 floods were blocked by national institutions, for example. At the same time, a residential area that was submerged during the floods was expanded.

Interviewees at the municipal level in Skedsmo argued that, in hindsight, the measures taken during and immediately after the floods were too complex. This was caused by too high prognoses for water levels, and that the measures taken after the

floods in 1967 were more effective than expected to meet the 1995 floods. Among the costly measures that proved unnecessary were dismantling of the telephone system in the town hall, and the electronic map databases. Overall, interviewees in Skedsmo said that the emergency planning had improved since 1995. Recurrent crises, including a gas leakage in 2000, have given the municipal administration experience and contributed to improving routines for emergency management.

3.3 Institutional factors shaping adaptation in Ringebu and Skedsmo

Two main features of the flow of information and learning and interaction of interests emerged as influencing municipal capacity to implement adaptation measures.

3.3.1 Lack of knowledge transfer between national and local levels

Ringebu and Skedsmo exemplify how municipal institutions interact with institutions at national and county levels to make decisions regarding vulnerability reduction. We found weak interlinkages in terms of knowledge transfer, sometimes perceived at the municipal level as top-down approaches of information generation and dissemination. This may impede adaptation measures at local level.

As illustrated in Figure 2, municipal level institutions and their decisions are linked to floods by two main routes. The first pathway (B) illustrates findings of how the floods triggered national efforts to assess damages after the floods and implement measures to avoid losses in future floods, such as increasing the availability of information such as flood warnings and maps of flood prone areas. Common for regulations and information services were that they were initiated from

the national level and implemented through the county governor or regional offices down to the municipalities, aiming to improve the local flood responses.

The other pathway (A) represents a direct response between floods and the municipality level. In 1995, municipalities implemented preventive measures and measures to restore damaged infrastructure. Examples include the decision to build a flood dike in Skedsmo, and the use of a map showing maximum flood levels for planning purposes in Ringebu. This "second route" is characterized by rapid responses, local initiatives (within the rules, regulations and funding schemes provided by the central government), supported by direct experience of flood impacts and local knowledge. This direct linkage has received less attention in national assessments, in terms of how decisions were formed at the local level, to what extent initiatives based on local knowledge about floods were incorporated in national level strategies, how adaptation decisions are formed in the local level institutions, and what are the potential conflicts and synergies between these parallel processes of response.

3.3.2 Technical bias

Both municipalities displayed a strong focus on technical flood defense. Flood protection is traditionally the domain of technical departments, which is reflected in a technical bias on proposed solutions such as building of dikes along rivers and drainage of sediments. Within the municipal administration, flood problems were also perceived as being caused by lack of technical protection schemes. Whereas the level of technical flood protection schemes in the Glomma-Lågen river basin is relatively low compared to other river basins in Norway and Europe, negative effects of such measures on fisheries and environmental protection are already apparent. One reason for the bias towards technical measures is likely to be an over-

representation of technically oriented expertise in municipal administrations, especially those departments concerned with flood management. It is reinforced by the kind of information and guidelines received from national level institutions: flood zone maps and guidelines for building and protection of infrastructure and technical installations implicitly focus attention on technical protection measures. In addition, construction of flood defences in Skedsmo, and draining of wetlands in Ringebu, demonstrated how high-profile physical structures may more easily receive national support (financially and politically) at politically opportune moments, such as after a flood event or during an election campaign.

There is increasing evidence internationally that technically oriented flood protection actually aggravates flood problems and also conflicts with the values of stakeholders and citizens (Tol et al., 2003). There is increasing recognition within NVE of the constraints a bias towards technical measures represents, and that rivers need to be given "space."[7] Both Skedsmo and Ringebu demonstrate the risk of "over-technification" where continued emphasis on technical solutions in municipal administrations could become a barrier to optimal flood management and vulnerability reduction. By treating flood adaptation as a one-off measure (technically oriented flood-protection measures) rather than a continuing process (incorporating new knowledge and climate change information, sometimes generated at national levels), they may find themselves vulnerable to changing weather patterns, such as increasing problems of intense rainfall events.

3.4 Is the municipality the appropriate level for decision making about climate adaptation?

The two case studies illustrate how social learning, conflicts of interest, and the way in which these interact across scales have several implications for municipal institutions as the appropriate level of adaptation.

The municipal level was subject to institutional factors that enhance and constrain its capacity as the appropriate level of adaptation. First, the local context-specific knowledge possessed by key individuals in municipal institutions was regarded as important as a basis for making decisions at the local level. This informal and in-depth knowledge of local conditions pertinent to flood risk was unique to the municipal or local level. Such knowledge may have contributed to the low numbers of lives lost (1) in the entire basin in 1995. However, municipal institutions may be vulnerable to the loss of valuable response and adaptation information due to a lack of institutionalisation and integration into formal systems.

Second, a bias towards immediate, one-off, technical measures was another outcome of interaction across scales that limited municipal adaptation capacity. Findings in Skedsmo suggested that measures were aimed at one particular climatic-derived factor (floods) rather than preparing the community at large for climatic variability in general. In addition, social adjustments and improvements in information flow of a more ongoing and long-term in nature were to a large extent ignored in both municipalities. There may be less attention paid to integrating local knowledge about the environment into routines, for example.

The above findings have potentially important implications for equity. Negotiation of interests that consistently results in technical interventions may benefit some more than others. Economic interests influenced decision-making towards construction of housing and businesses in flood-prone areas, along with flood-protection structures. Interests that may stand to lose from decision making

skewed towards technical measures include environmental interests where environmental qualities of the land are lost and, indirectly, the taxpayers who essentially pay for expensive measures. Technical measures may also simply 'move' a flood problem to other geographic areas or even create other environmental problems, potentially influencing the vulnerability of other municipalities negatively.

An important feature that emerged from the analysis was that some types of measures involved in adaptation may be outside the scope of the municipal institutions. First, holistic environmental management that might ensure greater equity between interests in adaptation could involve action at a river basin or county scale rather than the municipal scale. For example, some environmental interests were better represented at county levels than at the municipal level. Second, municipal institutions were limited by an increasing economic squeeze the causes of which are largely beyond the sphere of influence of individual municipalities. One of the main processes currently affecting municipal capacity is the devolution of responsibilities from national to municipal level institutions. At the same time, the financial framework within which these institutions operate is increasingly constrained, putting decision makers in an economic squeeze. In addition, the technical expertise may also be under stress, particularly in small municipalities, such as Ringebu.[8] Aall and Groven (2003) suggest that municipalities increasingly have to prioritize the pressing problems, such as schools and social services. Addressing other long-term issues such as preparing for future events or climatic changes then becomes difficult, as costs are incurred now but short-term gains are limited. This tendency may be reinforced by the perception that the government will cover costs associated with major climate events with compensation schemes. The

role of insurance in buffering costs has been observed by Teigland (2002) regarding other extreme events in Norway.

What general lessons can be drawn from the above two cases regarding the optimal level of adaptation? The findings suggest that while the local level is critical, adaptation in terms of reducing vulnerability may require measures carried out at several different scales. Addressing the above barriers to adaptation requires measures that are beyond the scope of the municipal level alone. Climate change adaptation measures targeted at enhancing local knowledge and the flow of information between national and local levels may include interventions at the national level. Furthermore, the technical bias of measures carried out at the municipal level suggests reforms of municipal structures or processes to ensure that a wider range of experts (including non-technical) and stakeholder interests be taken into consideration. Some of the contributing causes to the technical and 'one-off measure' approach to vulnerability reduction may be rooted in national processes, however. Technical measures are partly facilitated by the largely technical information received from the national level and the willingness of national institutions to fund large-scale physical measures after a dramatic event.

4 Conclusions

This study investigated responses to reduce vulnerability in terms of decisions made at the municipal level regarding flood-prone areas. These responses demonstrate features of the way in which information flow and learning, and conflicts (or convergence) of interests affect decision making and adaptive capacity. Main features of the responses to the 1995 floods in Skedsmo and Ringebu include:

- A bias towards technical aspects of flood management at the expense of social and environmental aspects
- A lack of recognition of local knowledge in formal flood management, and dependence on key knowledgeable persons
- Scepticism from the municipal level towards national level guidelines and measures

This study does not provide a comprehensive review of the role of all institutions, formal and informal, in adaptation to climate change. The investigated interactions regarding, for example, social learning, provide a starting point for understanding the capacity of institutions to reform in response to climate change. These are issues that can be investigated in more detail. Another aspect of adaptation to climate change is its integration in economic and social planning, a process which was not specifically investigated but of which there are few if any known cases in Norwegian municipalities. This is likely to be a crucial element in adaptation, however.

While there are limits to the extent to which findings from two cases can be generalised, the identified barriers and incentives to adaptation may be instructive to local adaptation in general. Significantly, the general constraints in adaptation carried out by formal institutions can provide lessons regarding geographic scales of adaptation as well as interaction across scales. These lessons add to current understanding of climate change adaptation, in particular regarding the local level as the optimal scale of adaptation. The study confirms the proposition by Cutter (2003) that appropriate measures demand local specific knowledge. However, institutional factors may limit the municipal capacity to carry out appropriate measures. In addition, there are adaptation measures that are outside the scope of the municipal

level. The study focused on social learning, conflicts of interest and their interaction across scales as institutional factors that may constrain or facilitate adaptation at the local level. Our findings underscore the observations by Olsson and Folke (2001), namely that co-management systems across scales can help increase the robustness in the face of external changes. In particular, we suggest that the ability to make decisions regarding the reduction of vulnerability is strongest when the linkages outlined in Figure 2, between an extreme event, national responses and local responses, reinforce each other. Interaction characterised by poor information flow combined with poor institutionalisation of local knowledge, represents a potential barrier to the development of effective adaptation measures. Another potential constraint is lack of attention and integration of informal knowledge systems in the formal flood response institutions, as shown in Figure 2.

The observed limits in tackling processes pertinent to adaptation that are beyond the scope of the municipality underscores findings elsewhere in the world regarding the causes of vulnerability. O'Brien and Leichenko (2000) argue that multiple pressures, including large scale socio-economic processes such as economic globalisation, shape vulnerability, in addition to climate change itself. In the context of local adaptation, the process of devolution of responsibilities from the central to municipal government may limit the financial and technical capacity of municipal institutions to carry out measures aimed at long term adaptation.

The findings confirm the need to lift our eyes beyond the local level even if the local is the topic of investigation, as suggested by Wilbanks (2002). Studying an event in-depth while examining linkages at least partly meets this challenge. The above framework can form the basis for future studies specifically on similar issues in other municipalities in Norway, as well as adaptation more generally. The factors

found to limit adaptation capacity in Ringebu and Skedsmo are likely to be no less relevant to the capacity of other municipalities in Europe to carry out measures. Many European countries have a lower degree of centralisation of management than Norway, implying that the coordination of adaptation measures and the flow of information between different municipalities and between institutions at different geographic scales may be even more complex than observed here. In principle, the new EU water directive aimed at enhancing basin-wide management of water resources is a step in the right direction in terms of adaptation. The findings in this study suggest that there are several potential challenges to its effective contribution to adaptation, however. These challenges include the integration of local knowledge, avoiding a flow of information and structures that are perceived as top-down, and resistance to change.

Our study demonstrates that in order for the local level to realise its potential as an optimal level of adaptation, flexibility of institutions and social learning are important prerequisites. It is likely that these prerequisites can only be addressed in combination with measures aimed at improving interplay and information flow between the national and municipal level. Adaptation to climate change therefore requires action both at the local and at the national level. In particular, identifying ways that 'direct' response can reinforce information flows between the national, county and municipal levels could contribute to strengthening decision making regarding the reduction of vulnerability at municipal level.

References

Aall, C. and Groven, K., 2003. Insitutional responses to climate change. Review of the contributions of four insitutional systems to climate change adaptation. (Institusjonell respons på klimaendringer. Gjennomgang av hvordan fire institusjonelle systemer kan bidra i arbeidet med å tilpasse samfunnet til klimaendringer.) Report 3/2003. Western Norway Research Institute, Sogndal. In Norwegian.

Adger, W. N. 2000a. Institutional Adaptation to Environmental Risk under the Transition in Vietnam. Annals of the Association of American Geographers 90(4): 738-758.

Adger, W. N., 2000b. Social and ecological resilience: are they related? Progress in Human Geography 24, 347-364.

Bakker, K., (ed.) (1999). A Framework for Institutional Analysis. Working Paper #3, Societal and Institutional Responses to Climate Change and Climate Hazards: Managing Changing Flood and Drought Risk (SIRCH), Environmental Change Unit, University of Oxford: 58 pp.

Blaikie, P., T. Cannon, I. Davis, and Wisner, B., 1994. At risk: Natural hazards, people's vulnerability, and disasters. Routledge, London and New York.

Brænne, J., 1995. Befaring og rådgivning for kulturetaten i Hedmark Fylkeskommune etter flommen i Østerdalen, juni 1995. Norsk institutt for kulturminneforskning – Norwegian Institute for Nature Research, Oslo. In Norwegian.

Brown, J.D. and Damery, S.L., 2002. Managing flood risk in the UK: towards an integration of social and technical perspectives. Transactions of the Institute of British Geographers 27, 412-426.

Burton, I., Huq, S., Lim, B., Pilifosova, O. and Schipper, E.L., 2002. From impacts assessment to adaptation priorities: the shaping of adaptation policy. Climate Policy 2, 145-159.

Cash, D.W. and Moser, S.C., 2000. Linking global and local scales: designing dynamic assessment and management processes. Global Environmental Change 10, 109-120.

Cutter, S., 1993. Living with Risk. Edward Arnold, London.

Cutter, S.L., 2003. The vulnerability of science and the science of vulnerability. Annals of the Association of American Geographers 93, 1-12.

Eikenæs, O., 2000. Living with floods. (Å leve med flaum). HYDRA project report. Norwegian Water Resources and Energy Directorate, Oslo. In Norwegian.

Eikenæs, O., Njøs, A., Østdahl, T., and Taugbøl, T., 2000. The flood is coming… (Flommen kommer...) HYDRA end of project report. Norwegian Water Resources and Energy Directorate, Oslo. In Norwegian.

Glantz, M., 1989. Forecasting by Analogy: Societal Responses to Regional Climate Change. National Center for Atmospheric Research and US Environmental Protection Agency.

Hindar, K., J. H. L'Abbee-Lund, Jensås, J.G., Møkkelgjerd, P.I., Balstad, T., and Arnekleiv, J.V., 1996. The effects of the 1995 floods on the population of salmon and trout spawn in Gaula. (Effekter av flommen i 1995 på bestanden av laks- og ørretunger i Gaula.) Norsk Institutt for Naturforskning, Trondheim. In Norwegian.

Lisø, K.R., Aandahl, G., Eriksen, S., and Alfsen, K.H., 2003. Preparing for impacts of climate change in Norway's built environment. Building Research & Information 31, 200-209.

Liverman, D.M. and Merideth, R., 2002. Climate and society in the US Southwest: the context for a regional assessment. Climate Research 21, 199-218.

Lundquist, D., Lunde, A.E., and Bøe, P.C., 1996. The 1995 floods in Glomma and Lågen. (Flommen 1995 i Glomma og Lågen.) Glommens og Lågens Brukseierforening, Oslo. In Norwegian.

Miller, K.A., Rhodes, S.L., and MacDonnel, L.J., 1997. Water allocation in a changing climate: Institutions and adaptation. Climatic Change, 35: 157-177.

Ministry of Environment and Ministry of Municipal and Local Government, 1997. Area planning and building in risky areas. (Arealplanlegging og utbygging i fareområde.) T-5/97. Circular. Oslo. In Norwegian

Morrow, B. H., 1999. Identifying and mapping community vulnerability. Disasters 24, 1-18.

Næss, L.O., forthcoming. The role of institutions for adaptation to climate change: Literature review and a framework for analysis, with particular reference to Norway. CICERO Working Paper, Oslo.

NIVA, 1996. The 1995 floods in eastern Norway. A comparison of NIVA investigations, with special emphasis on the measurement programme in Glomma and Vorma. (Flommen på Østlandet våren 1995. Sammenstilling av NIVAs undersøkelser med spesiell vekt på måleprogrammet i Glomma og Vorma.) Norsk Institutt for Vannforskning, Oslo. In Norwegian.

NOU, 1996. Measures against floods. (Tiltak mot flom.) Norges offentlige utredninger, Oslo. In Norwegian.

NVE, 1999. New/revised guidelines for use of flood prone areas. Guidelines 1/1999 – land use and safety in flood prone areas. (Nye/reviderte retningslinjer for bruk av areal i flomutsatte områder. Retningslinjer 1/1999 -Arealbruk og sikring i flomutsatte områder). Norwegian Water Resources and Energy Directorate, Oslo. In Norwegian.

Nye, J., 1987. Nuclear learning and US-Soviet security regimes. International Organization, Vol. 41, No. 3.

O'Brien, K., Sygna, L., and J.E. Haugen, In Press. Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. Climatic Change, Forthcoming.

O'Brien, K.L., and Leichenko, R.M., 2000. Double exposure: assessing the impacts of climate change within the context of economic globalisation. Global Environmental Change 10, 221-232.

Olsson, P. and C. Folke, 2001. Local Ecological Knowledge and Institutional Dynamics for Ecosystem Management: A Study of Lake Racken Watershed, Sweden. Ecosystems 4(2): 85-104.

Quarantelli, E.L. 1987. What should we study? Questions and suggestions for researchers about the concept of disasters. International Journal of Mass Emergencies and Disasters 5, 7-32.

Roald, L.A., 2002. The large flood of 1860 in Norway. Norwegian Water Resources and Energy Directorate, Oslo.

Skurdal, J., Østdahl, T., Taugbøl, T., Kaltenborn, B.P., Hertzberg, K., Arnesen, T. and Hagen, S.E., 2000. The Glomma and Laagen River Basin in Norway. WCD Case Study. Secretariat of the World Commission on Dams, Cape Town

Smit, B. [et al.], 2001. Adaptation to Climate Change in the Context of Sustainable Development and Equity (Ch. 18). In McCarthy, J.J., Canziani, O.F., Leary, N.A.,

Dokken, D.J. and White, K.S. eds. Climate Change 2001. Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Teigland, J., 2002. Socio-economic effects of extreme weather in Norway – a study of the effects over time and in space of the New Year's storm in 1992. (Sosioøkonomiske effecter av ekstremt vær i Norge – en studie av effecter I tid og rom av nyttårsorkanen 1992). Report 7/2002. Western Norway Research Institute, Sogndal. In Norwegian.

The Heinz Center, 2002. Human Links to Coastal Disasters. The Heinz Center, Washington DC. www.heinzctr.org.

Tol, R.S.J., van der Grijp, N., Olshoorn, A.A., and van der Werff, P.E., 2003. Adapting to Climate: A Case Study on Riverine Flood Risk in the Netherlands. Risk Analysis, 23(3): 575-583.

Vayda, W.P. and Walters, B.B., 1999. Against political ecology. Human Ecology 27, 167-179.

White Paper no. 37, 1995-96. (St. meld. nr 37) Om flommen på Østlandet 1995 og kriseberedskap i fred. In Norwegian.

White Paper no. 42, 1996-1997. (St. meld. nr 42) Tiltak mot flom. In Norwegian.

Wilbanks, T.J., 2002. Geographic scaling issues in integrated assessments of climate change. Integrated Assessment 3, 100-114.

Wilbanks, T.J. and Kates, R.W., 1999. Global change in local places: how scale matters. Climatic Change 43, 601-628.

Yin, R., 1994. Case study research, design and methods. Sage Publications, Thousand Oaks, London, New Delhi.

Yohe, G. and Tol, R. S. J., 2002. Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. Global Environmental Change 12, 25-40.

Young, O., 1998. Institutional Dimensions of Global Environmental Change, Science Plan. IHDP Report No. 9. [online: http://www.ihdp.uni-bonn.de/html/publications/reports/report09/]

Øygarden, L., Eggestad, H. O., Standring, W.J.F. Goffeng, G., and Vagstad, N., 1996. The 1995 floods. Damages to agricultural land along Glomma and Gudbrandsdalslågen. (Flommen i 1995. Skader på jordbruksarealene langs Glomma og Gudbrandsdalslågen.) Jordforsk - the Norwegian Centre for Soil and Environmental Research, Ås. In Norwegian.

Table 1. Examples of key formal institutions relevant for flood management in Norway

Level	**Institutions**				
	Water resources management	*Civil defence and emergency planning*	*Environmental and resources management*	*Area planning*	*Insurance*
National /Policy level	• Legislation on river flow • Regulations for flood protection • Mapping of flood zones • Issuing of flood warnings	• Legislation on civil defence and emergency plans • Regulations for crisis management • Advice on risk and vulnerability assessments	• Legislation on ecosystem protection • Programs for river delta protection • Protection of rivers from hydropower use	• Legislation on area planning • Regulations of the use of flood-prone areas • Settlement of planning disputes	• Legislation for damage compensation from natural perils (govt., private) • Rules for pool of natural perils • Settling of damage claims
County /Regional level	• Planning and advice on flood protection • Implementation of water flow regulations • Distribution of flood warnings to municipalities	• Coordination of information /resources during emergencies • Contingency planning in County Emergency Council	• Advice on national management policies • Advice and distribution of state grants	• Advice on municipal planning • Development of county area plans • Overseeing of national planning regulations, mediating disputes	
Municipal /Local level	• Implementation of new flood protection measures • Monitoring of existing flood protection schemes	• Reporting to County Governor during crises • Municipal Emergency Council • Risk and vulnerability assessments	• Implementation of environmental policies	• Responsibility for area planning • Responsible for actions to avoid flood damages • Undertaking of risk analysis related to planning	• Reporting and assessment of damages from natural perils

Footnotes

[1] We define social learning as "the development of new knowledge by study or experience. New information alters prior beliefs about the world, and awareness of newly understood causes of unwanted effects often results in the adoption of different, and more effective, means to attain one's ends," Nye, J. (1987), pp. 378-379.

[2] www.ringebu.kommune.no

[3] Although not discussed in this paper, institutions themselves also affect the "requirements" for flood damage, i.e. whether a flood will occur at a certain water level and how severe it will be (Bakker, 1999).

[4] The map was based on aerial photos taken during the floods.

[5] Parts of the flood dike was built at 105.5 m.a.s.l., where temporary dikes could be raised in an emergency situation.

situation.

[6] Are Mobæk, Director of Water Resources Department, NVE, Personal communication

[7] Presentation by Are Mobæk, Director of Water Resources Department, NVE, at conference organized in connection with the International Water Year, Bergen, 6 May 2003 (www.nve.no)

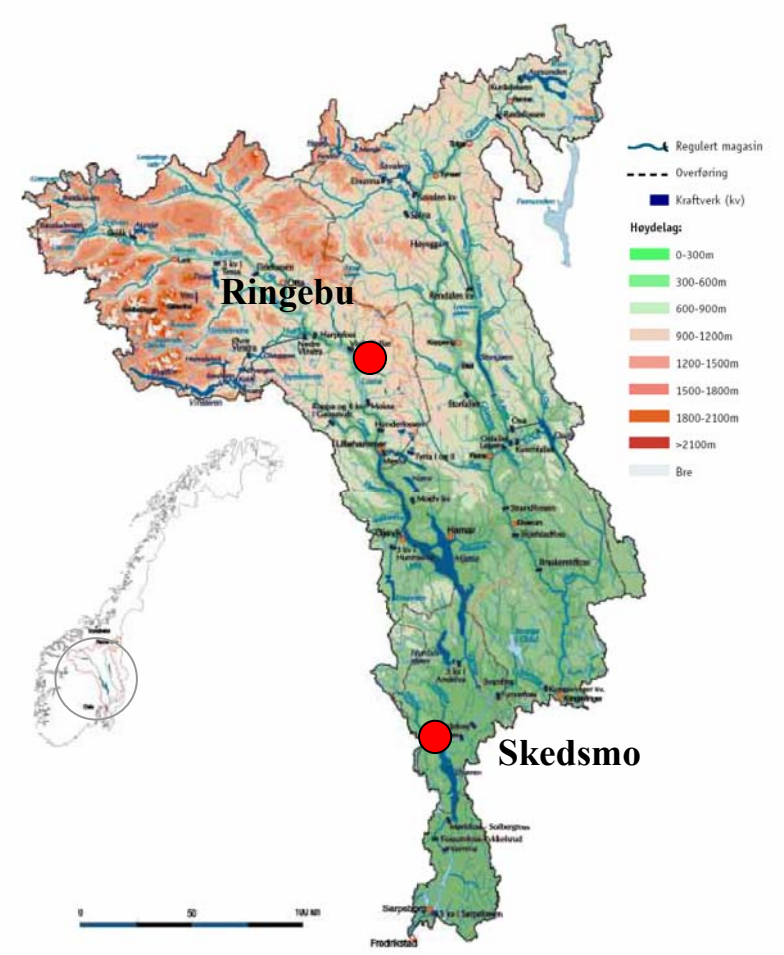
[8] According to a newspaper report 26. November 2003 Ringebu were considering deep budget cuts to save money, including removing the position of municipal environment officer and an engineer in the technical department (*Gudbrandsdølen Dagningen*, 26. November 2003; http://www.gd.no/vis_sak.asp?refnum=10618 (*in Norwegian*)

Captions to illustrations

Figure 1. Map of the Glomma/Lågen river basin (Eikenæs 2000)

Figure 2. Flood events and interaction and information flow among institutions

Illustrations



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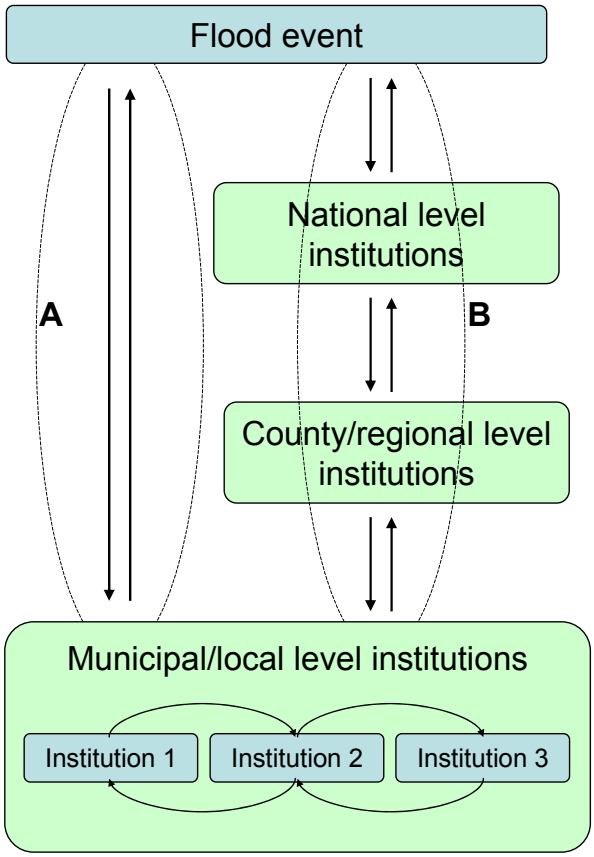

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