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Climate change and the resilient society: utopia or realistic option for German regions?

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Abstract For the last five years, climate change has been increasingly perceived as a challenge for regional development. Compared to other nations, Germany is relatively 'safe', but the German regions are prone to different impacts of climate change; some of them might be positive but most will be negative in the long run. Strategic concepts are therefore needed to reduce the negative impacts and use the potential positive effects. Due to enforced research funding, several German regions are currently developing adaptation strategies within transdisciplinary research projects. Based on a comparative case study analysis of three of these projects, this paper looks for the benefits of resilience thinking in the context of climate change adaptation. The analysis shows that the case study regions try to increase their resilience to climate change by strengthening the properties of (1) resistance, (2) recovery and (3) creativity. But the discussion also reveals that only parts, certain sectors or subjects, of the region can increase their distinct resilience. Regional stakeholder networks as established within the case study regions can make a significant contribution to linking different sectors and levels of action. Therefore, this approach seems to be applicable for integrating the need for adaptation within the whole region. It is believed that the regionalized communication of potential climate change impacts raises awareness for climate change adaptation, helps to develop appropriate adaptation measures and encourages action. Hence, different approaches can indeed lead to more resilient structures. But the resilient society at regional level remains utopia.

Keywords Resilience · Climate change · Regional adaptation strategies · Regional development · Bottom-up approach · Participation · Stakeholder networks

1 Introduction

Until recently, scientific debate on climate change had been on questions about whether climate change is already occurring or will occur at all and what adequate mitigation

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measures had to be. But latterly, since the release of the Fourth Assessment Report of the International Panel on Climate Change (IPCC) in 2007, the focus shifted from only scientific to public and political discussions. And by accepting that there is and will be (human-induced) climate change, the attention also shifted from mitigation to adaptation strategies (Dovers 2009).

The IPCC states that strategic and participatory adaptation is occurring, and some scholars see adaptation already *'becoming a mainstream policy response for addressing […] climate change'* (Preston et al. 2009: 1). Others remain critical because of the significant gap between adaptation planning and implementation (Repetto 2008).

Within this context, the vision of resilient society gains relevance as the concept of resilience comprises three components important to cope with (climate) change. These are the capacity (1) to resist and (2) to recover from disturbances and shocks and (3) to adjust functioning—prior to or following—changes and disturbances.[1] The latter corresponds to high adaptive capacity and ability for learning and self-organization (Folke 2006; Smit and Wandel 2006).

According to Berkes, this will enable society *'to move toward the kind of institutions […] that take advantage of new opportunities, mitigate the worst impacts, and allow for the necessary learning and innovation to cope with a new climate regime'* (Berkes 2007: 287). But so far, according to Füssel (2007) the resilience approach has not been widely applied in the climate change context. This paper therefore looks at the potential benefits that resilience thinking might bring to the climate change and adaptation debate. An empirical basis builds the analysis of climate change adaptation strategies at regional level in Germany.[2]

As central challenges opposing climate change adaptation and the climate change resilient society, the following will be discussed:

- Deficit of knowledge and information: in public, there is still a widespread lack of awareness concerning the necessity of climate change adaptation. This is, to some extent, due to still lacking (scientific) knowledge but—more important—because knowledge is available but not used appropriately (White et al. 2001).
- Deficit of motivation: effective informatory measures can lead to increased awareness. But denial, disbelief and downplay of the given information might follow as well as wrong appreciation and evaluation of potential climate change impacts (Grothmann and Patt 2005).
- Deficit of implementation: even strong awareness and motivation do not automatically lead to application of adequate adaptation measures. And—if occurring—adaptations are seldom an answer to climate change impacts alone. Therefore, to really affect

[1] This definition refers to the broad socio-ecological understanding of resilience elaborated by the Resilience Alliance (e.g. Berkes et al. 2003; Carpenter et al. 2001). Although the Resilience Alliance focuses mainly on ecosystems when analysing socio-ecological resilience, their definition seems to be applicable to social systems as well—especially since recent advances in resilience research *'include understanding of social processes, like social learning and social memory, mental models and knowledge-system integration, visioning and scenario building, leadership, agents and actor groups, social networks, institutional and organizational inertia and change …'* (Folke 2006: 253).

[2] In the German context, a region is understood as sub-national, sub-state but supra-local level. The region therefore is at intermediate level in-between federal state and local authorities. Although not organized administratively in Germany, the region is an important level of action for climate change adaptation. Hence, many policies and research programmes on integrating climate change adaptation into technologies, procedures and strategies focus on the regional level (cp. Sect. 3.1).

implementation, decision processes have to be considered (Hallegate 2009; Smit and Wandel 2006).

The aim of this paper is to apply the concept of resilience to the aforementioned challenges of climate change adaptation. Based on a comparative case study analysis of regional climate adaptation strategies in Germany, examples of the aforementioned obstacles and how to overcome them will be discussed.

2 Impacts of climate change: the need for adaptation

Worldwide the impacts of climate change will meet the regions differently (IPCC 2007). Especially the highly urbanized and densely populated regions are facing a high vulnerability and an immense loss potential (Stern 2006). Günther et al. (2007) for example state that since 1980 in Europe 64 per cent of all natural disasters and 79 per cent of the resulting economic damages relate to extreme weather phenomena and gradual climate change. Their concept for resilience management in enterprises builds on the distinction between a trend component and ad hoc disruptions or discontinuities due to climate change. Ad hoc impacts are defined as extreme weather events like hurricanes, hailstorms or droughts and are subsumed as 'ecological discontinuities'. These ecological discontinuities have effects on socio-economic systems and increase risks for enterprises. Günther et al. therefore underline the importance of considering unexpected ad hoc impacts of climate change in business management. This rationale is in line with 'managing the unexpected' as discussed by Weick and Sutcliffe in their seminal book (2007). With a similar tenor, Hallegate recently discussed strategies to adapt to climate change, focusing the uncertainty regarding future climate conditions as a special challenge for decision making. He states there is a significant rise in awareness about climate change. But, due to the increase in uncertainty about the future climate, new decision-making tools have to be developed to cope with the impacts of climate change. Hence, 'if uncertainty is taken into account in all long-term decisions, many infrastructure projects will be better adapted in the future, and climate change impacts will remain lower and more manageable' (Hallegate 2009: 246). But it is not only the increase in extreme weather events that imperils socio-economic and socio-ecological systems. Also, the gradual or 'incremental' change in climate conditions like the raise in temperature and the change in precipitation patterns will affect society, economy and the environment in a way that has to be considered. The effects of climate change will therefore not only meet some especially sensitive landscapes but nearly all areas of life (IPCC 2007).

Adaptation to the unavoidable impacts of climate change is therefore needed, besides the further mitigation of climate change.[3] Whether and how adaptation occurs depends on the adaptive capacity[4] or the resilience of a system. Adaptive capacity and resilience are different but clearly linked conceptual approaches that emerge from different disciplines. A clear distinction between these (and other related concepts such as coping capacity, exposure, preparedness, response, sensitivity, susceptibility, vulnerability) has not been

[3] The IPCC defines adaptation to climate change as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects. This adjustment moderates harm or exploits beneficial opportunities. The IPCC further distinguishes various types of adaptation including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC 2007).

[4] The IPCC identifies adaptive capacity as a function of wealth, technology, education, information, skills, infrastructure, access to resources, and stability and management capabilities (McCarthy et al. 2001).

mainstreamed so far (Birkmann et al. 2009; Schipper and Burton 2009). Both are somewhat generic concepts whose main characteristics and driving factors often overlap. As a broad body of literature already exists on the correlation between adaptive capacity and adaptation (e.g. Smit and Wandel 2006; Adger 2006; Grothmann and Patt 2005; McCarthy et al. 2001), this paper focuses on the interrelationship between resilience and climate change adaptation looking for potential benefits of resilience thinking (see chap. 3 for discussion).

3 Considering the regional level

The geographical location and current as well as planned land use patterns are crucial factors determining a region's vulnerability to the impacts of climate change. Adaptation strategies oriented on administrative boundaries may not be congruent with the areal impacts of climate change. Adaptation strategies rather focus on areas that have to cope with similar consequences of climate change. Seen from this angle of potential affection, the region is an important spatial reference level (Patterson et al. 2006; Smith and Mendelsohn 2006). Furthermore, the region is crucial at intermediate level within the context of national and local responsibilities. This is because most adaptive responses have to be made at the sub-national level—even if national or international policies may facilitate or constrain adaptation (von Storch and Meinke 2008; Ruth et al. 2006; O'Brien et al. 2004; Adger 2001).[5] In a position paper to the European Commission's Green Paper 'Adapting to climate change in Europe—options for EU action' the Academy for Spatial Research and Planning (ARL) in Hanover, Germany, therefore states that *'Particular attention in this context should be paid to the regional and local levels as many forms of adaptation to climate change can only be mapped at the regional level, and, in political terms, their course can only be steered by actions taken on a local scale.'* (ARL 2007: 6).

3.1 Adaptation policies and strategies: the German regions context

By agreeing on the United Nations Framework Convention on Climate Change (UNFCCC), all contracting parties have been obliged to formulate and implement national and, where appropriate, regional adaptation strategies (UNFCCC 1992). Due to an initiative of the UNFCCC, the developing countries have been engaged in drafting National Adaptation Programmes (NAPAs). But in contrast there is no uniform policy of climate adaptation to be stated concerning the industrialized countries—although Canada, Finland or the Netherlands can be seen as pioneering countries. In Germany, a national adaptation strategy (Deutsche Anpassungsstrategie = DAS) was enacted in December 2008 (The Federal Government 2008). The DAS as contribution of the German Federation builds the overall framework for adaptation to climate change impacts in Germany aiming to give orientation for other actors. On this basis, the federal states of Germany and all societal groups now have to start a process of risk identification, definition of needs for action, according goals and possible adaptation measures. Until March 2011, an 'Action Plan' will be followed.

[5] Von Storch and Meinke (2008) therefore promote the use of Regional Climate Offices to communicate between the scientific sphere and the regional public sphere. In 2008 the Helmholtz Association, as Germany's largest scientific organization, has established a network of four regional climate offices in Germany. Each of the four Regional Climate Offices is focusing on a certain region (North, South, Central Germany and the Polar Regions).

Some of the German federal states have already been working on climate adaptation, drafting adaptation strategies and action plans (e.g. North Rhine-Westphalia, Saxonia) or respective funding programmes at the state level (e.g. Lower Saxony).

Additionally, several regions are working on regional adaptation strategies. These regional activities are mainly within the context of research programmes that explicitly fund the development of regional adaptation strategies. The German Federal Ministry for Education and Research, for example, is financing research on dealing with climate change within two funding programmes 'klimazwei—research for climate protection and protection from climate impacts' and 'Managing climate change in the regions for the future (KLIMZUG)'. The klimazwei programme has been running since 2006. It has funded 40 joint projects in which tangible solutions—both for climate protection measures and for adaptation to climate change—have been developed. Users from business and civil society have been involved through transdisciplinary research cooperation. Within the strand of adaptation projects focused on the development or improvement of early warning systems, drainage concepts, adaptation measures for field crops, modified touristic services, measures for regional planning and urban development or decision support systems in forestry and agriculture, just to cite a few topics. The identified need for more research into the development of integrated regional strategies for adaptation to climate effects directed the launch of KLIMZUG. This new programme was started in 2008 and focuses explicitly on the regional aspects of climate change adaptation. It fosters regional networks of actors from science, business, administration and public agencies. The anticipation of changes in the processes of regional planning and development and the implementation of concrete climate adaptation measures is to be achieved.

Another research programme funding regional climate adaptation strategies is the action programme 'Demonstration Projects of Spatial Planning' (MORO) by the German Federal Ministry of Transport, Building and Urban Affairs. MORO programmes generally support practical trials and the implementations of innovative action-oriented approaches of spatial planning instruments in cooperation with science and practice, i.e. together with various stakeholders in the regions. In June 2009, a new MORO programme on 'spatial development strategies for climate change' started supporting eight model regions. The main task of these regions is the development of climate mitigation and adaptation strategies (specific to their region) by applying and refining the instruments of comprehensive spatial planning.

3.2 Three case studies

The funding programmes described earlier instigated a range of activities in the German regions. But apart from the funded projects, there are still few initiatives on the development of regional adaptation strategies. The following paragraphs take closer looks at three projects from the above-mentioned 'klimazwei' programme. These three projects have been selected for analysis as they fulfil the following criteria:

- they refer to regions that differ in respect of their natural landscape units, settlement patterns and economic structure,
- they cover various fields of action (e.g. agriculture, forestry, spatial planning, water resources management, health, tourism),
- they have been running now for more than three years and have produced sufficient outcome to draw some conclusions and
- they have a certain reputation within the scientific community and can be regarded as best practice projects.

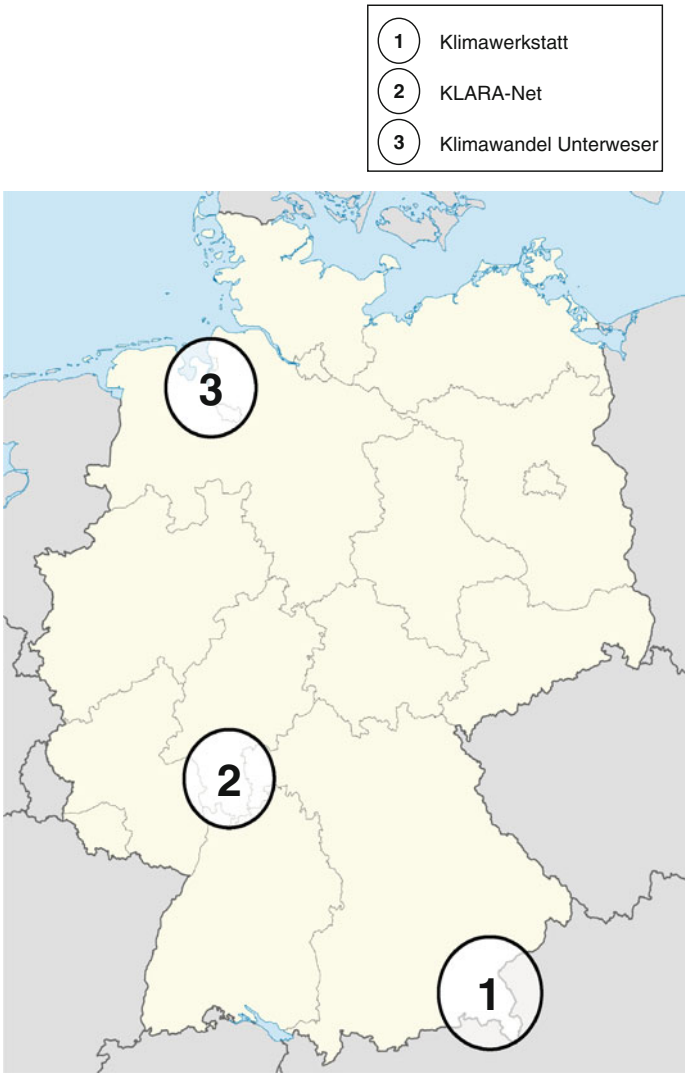

Fig. 1 Location of the three case study regions

3.2.1 'Klima-Werkstatt': climate workshop

Far in the South of Germany, located in Chiemgau, the 'Klima-Werkstatt' mobilizes and pools regional stakeholders willing to contribute to climate-related projects. Due to the size of the region and its different landscape units, the expected impacts of climate change are manifold. They reach from an increased risk of flooding esp. at smaller rivers or streams to the decrease in water supply, from an increased yield potential within agriculture and forestry to a growing risk of droughts. The Klima-Werkstatt does not focus on either climate mitigation or adaptation but integrates both challenges within its projects and

messages. 'Energy and trade', 'agriculture and water' and 'consumer/population mobilization' are the three fields of action in which various pilot projects run to motivate regional actors. For example, the Klima-Werkstatt initiated a 'Regional Forum on Strengthening Grassland', which improves the link between water management and agriculture. Here, the training and networking of regional water advisors and local communities to prepare for climate change are just as important as the training in agricultural farms. Furthermore, the regional forum provides various informative events and workshops for strengthening the grassland to protect its multi-functional effects with regard to resource conservation and society. Another pilot project is the concept for climate-friendly building (including training opportunities for architects, planners, energy consultants and craftsmen) that has been developed. The main characteristic of the Klima-Werkstatt project is the stakeholder-oriented approach. The first step was the identification of dedicated people from the region. Then, they analysed what kind of support they needed to develop their own climate-related project ideas. This resulted in the various stakeholder groups on the pilot project level receiving exactly the knowledge and technical support they required for their specific climate protection and/or adaptation options. The Klima-Werkstatt strengthens awareness on potential regional impacts of climate change and activates different target groups, as well as the broad population, to look and plan ahead. The project expands commitment to climate change mitigation and adaptation by communicating the added value of climate-gentle products and services. Within this context, for example, consumer behaviour changes with an effect on climate have been investigated. A six-month test period has been run comparing everyday life in different households and their behaviour in the areas of food, consumption, energy and mobility. As a result, all participants learnt about their specific carbon footprint and how to reduce it easily in their daily routines. During the term of the funded research project, the Klima-Werkstatt provides demand-oriented knowledge transfer, develops possibilities for stakeholder participation and supports regional project promoters. In the long run, the stakeholder network shall become a self-supporting structure, if possible organized as a foundation.

3.2.2 'KLARA-Net': network on climate change adaptation in the region of Starkenburg

In a similar approach, the project KLARA-Net builds up a network of regional stakeholders who develop individual adaptation options. These stakeholders serve as 'multiplicators' within their spheres of activity. The region of Starkenburg as part of the economic prosperous Rhine-Main area faces a high loss potential as the risk of flooding esp. in spring increases owing to shifting precipitation patterns and an increase in extreme rainfall events. Furthermore, the expected strongest warming compared to other german regions will cause an increasing vulnerability of certain sectors, i.e. tourism or the health sector. KLARA-Net builds on four fields of action that are as follows: 'spatial planning + building industry + water resources management', 'agriculture, viniculture + forestry', 'tourism' and 'health'. Each of these fields of action is operationalized by a working group. In addition to the regular meetings of the thematical working groups, regional forums are held twice a year. So far, KLARA-Net has made an expedient contribution to several processes of regional development (e.g. by formulating position papers on the new regional development plan, on agro-environmental funding programmes, on technical guidelines for cost-effective construction within the public sector). KLARA-Net has also developed tangible products like a climate adaptation checklist for local authorities or a hiking trail on spring water. Advancing further with the integrated approach, the ongoing project work will be increasingly dedicated to the observation of interfaces. These include content-related links between the thematic

groups on the one hand and stronger links between regional knowledge and the superior administrative levels and political authorities on the other hand, thus facilitating action recommendations for policy areas that are relevant for adaptation to climate change. In a pilot area (one special part of the whole region, identified by a regional competition), an adaptation concept plus initial concrete adaptation measures will be produced and implemented. The alliance of regional actors working on the pilot area project was built on the initiative of regional stakeholders. Supported by the Technische Universität Darmstadt (which provides, for example, technical advice and moderation of working group meetings), this alliance of regional actors has the sole responsibility for contents and implementation of the adaptation concept that is going to be developed. The activities encouraged by KLARA-Net not only illustrate measures to cope with and reduce climate-related risks, they also point out the potential for new products, public services and business processes.

(For more information: www.klara-net.de).

3.2.3 'Klimawandel Unterweser': climate change in the river Weser basin area

Focusing on a North Sea coastal region that is part of the metropolitan area of Bremen/Oldenburg, the project Klimawandel Unterweser developed climate change adaptation strategies in dialogue with regional actor groups and the general public. As a coastal area, the Unterweser region is threatened by possibly more intensive storm surges and the rising sea level. Futhermore, it faces—as nearly all german regions—shifting precipitation patterns with various consequences on flood risk and general water supply. Within the project Klimwandel Unterweser, new forms of communication for measures of adaptation to climate change were tested with stakeholders from the sectors 'agriculture', 'tourism' and 'urban and regional planning'. To ensure further impulses, the stakeholders had been selected on the basis of the following criteria:

- Concernment: person is from the area and is concerned by the impacts of climate change on the area,
- social representation: person is representative of an actor group of the region,
- function as multiplicator: person is capable of transferring results from the projects into other societal institutions,
- potential of influence: person has certain influence on decision processes regarding the economic, societal or ecological development of the region,
- status as expert: if possible, the person relates to the realm of environmental or climate protection,
- diversity: all societal groups shall be represented,
- continuity: actors are committed to continuous participation and
- gender: an equal allocation of gender is the aim.

A series of workshops aimed at active engagement with the potential effects of climate change on the Unterweser region and development of jointly shared strategies and concepts to cope with climate change. Following a five-step approach on 'recognizing', 'giving information', 'acting', 'creating' and 'exchanging', the stakeholders developed six products. These products had to meet the following criteria: innovative access on the subject of climate change adaptation, time-wise and spatially flexible in application, wider environment interested, transfer potential available, presentability given, cofinancing by the target group and takeover of responsibility for production by the target group. The products were tested and improved during the last project phase on diffusion and transfer. Now, the following have to be implemented, used and continued by the different target groups:

(1) the touristic 'climate change theme tour', (2) a campaign on 'climate qualification' of tourism professionals, (3) a manual on 'Climate Adaptation in Planning Policy', (4) the modelling of a regional water management system, (5) the integration of climate change into the agricultural basic education, and (6) the 'climate theatre' (as a further communication measure). As the Unterweser region is part of a larger north-west German region that became one of the seven KLIMZUG model regions, all results, experiences and the stakeholder network will merge in this new practice-oriented research project called 'nordwest 2050'. This brings the opportunity to further improve the region's ability to deal with climate change in selected fields and to integrate these improvements into regional planning and development processes. (For more information: www.klimawandel-unterweser.de).

3.3 Obstacles and constraints for adaptation to climate change

As shown, the regions are located in three very different natural landscape units of Germany (foothills of the Alps, Upper Rhine rift, North Sea coast) and are characterized by different settlement patterns (from rural to densely populated areas) and economic structure (from agriculture/forestry, industry and trade to services). But although the basic conditions differ, the three projects have many aspects in common and had some similar experiences regarding the difficulties of developing regional adaptation strategies on climate change.

All three projects are based on the assumption that there are three deficits that need to be tackled:

1. *The deficit of knowledge and information:* Although global warming and climate change are hot topics in the global mass media the general public still lacks awareness concerning the necessity of climate change adaptation (Weber 2006). This is to some extent due to still lacking (scientific) knowledge but—more important—because knowledge is available but not used appropriately (White et al. 2001). Hence, the projects do not put an effort into modelling further regional climate change scenarios. They rather grasp the manifold information on the impacts of climate change on German regions provided by prominent research institutions like the Max Planck Institute for Meteorology or the Potsdam Institute for Climate Impact Research. The region's vulnerability to climate change is estimated but not assessed precisely.[6] This information is then communicated target group orientedly by using different 'languages' and by filtering or tailoring the information to bridge the gap between scientific language and the way lay people communicate.
2. *The deficit of motivation:* Effective informatory measures can lead to increased awareness. But denial, disbelief and downplay of the given information might follow, as well as wrong appreciation and evaluation of potential climate-change impacts (cp. Grothmann and Patt 2005) or distrust in decision making (cp. Löfstedt 2009). Tackling these problems is not trivial as there has still been very little analysis of the psychological dimensions of adaptation (cp. O'Brien 2009). The case study projects therefore chose 'bottom-up' approaches, based on actor and motivation analyses believing that this strong stakeholder orientation leads to more commitment. The project Klimawandel Unterweser showed the most stringent actor analysis. But the other two projects also strongly focus on their regional stakeholders. They follow

[6] As Adger states 'enough is known about vulnerability and resilience in most circumstances to provide robust information to decision-makers' (Adger 2006: 278).

Folke (2006: 262) with an understanding that 'individual actors play essential roles in providing e.g. leadership, trust, vision and meaning, and in social relations, e.g. actor groups, knowledge systems, social memory. Social networks serve as the web that seems to tie together the adaptive governance system'.[7] The projects furthermore rely on a transfer of knowledge by dedicated actors operating as diffusion promoters/agents and they test whether the complex topic of climate change is better accessed by emotion using theatre or art as communication tools.

3. *Deficit of implementation:* Even strong awareness and motivation does not automatically lead to application of adequate adaptation measures. And—if occurring—adaptations are seldom an answer to climate-change impacts alone. Therefore, to really affect implementation, decision processes have to be considered and additional incentives have to be set (Hallegate 2009; Smit and Wandel 2006). To facilitate implementation, the case study projects try to involve relevant actors. It is assumed that performance can be brought forward if those who are or will be affected by climate change and those who have to realize adaptation measures take part in the analysis of potential impacts of climate change and in the development of appropriate adaptation measures. The trial of measures in the context of regional pilot projects is an additional tool to foster implementation.

Will the three regions' activities be sufficient to overcome the mentioned deficits? Are the projects actually able to increase adaptive capacity and readiness for action in these regions?

The following section explores the concept of resilience, looking for evidence of whether resilience thinking can help to bridge the gap between adaptation planning and implementation with regards to dealing with the deficits of knowledge, information, motivation and implementation. After conceptualizing resilience, the case study results will be discussed anew.

4 The concept of resilience as solution? conceptualizing resilience

It is widely assumed that more resilient regions (or more general systems, communities or societies) are better prepared for the impacts of changing conditions like climate change will bring (UN/ISDR 2004). Resilience therefore is regarded as a desirable property of human and natural systems although there is no common understanding of its meaning. The different definitions existing of the term 'resilience' can be explained by the broad range of scientific communities using the concept. Emerging from ecology in the 1960s and 1970s, resilience today still is a core concept used by ecologists measuring the ability of ecosystems to absorb disturbances and shocks, and still persist (Folke 2006; Holling 1973). However, even in ecology there is no clear and uniform understanding of resilience. Now the concept of resilience is also used in the realm of social systems (e.g. Maguire and Hagan 2007; Adger 2000), socio-ecological systems (Berkes et al. 2003; Walker et al. 2002) and socio-economic systems (e.g. Günther et al. 2007; Comfort et al. 2001).

[7] The actual participation in different working groups ranges between 5 and 20 members whereas certain thematic workshops or informative events for the broader public attract up to 150 people. The analysis of the actor's motivation and engagement furthermore allows distinguishing different roles or categories of actors. These are about 20 'doers' (3–4 per subject, resp. project or working group) who drive the development of tangible adaptation options or products. Together with about 30 'allies' the doers form the active centre or hub of the regional network on climate change adaptation (cp. Frommer 2010).

Timmerman (1981), who was one of the first to link the concepts of resilience, vulnerability and adaptation and to apply this to the context of climate change, understands resilience very similarly to Hollings' definition as a measure of the ability of a system to absorb and recover from pre-current disturbances. Following Timmerman's interpretations on reliability and resilience, Dovers and Handmer (1992) suggest the distinction between *reactive* and *proactive* resilience when applying the concept of resilience to human society. Reactive resilience is understood as the ability of a system to strengthen its resistance, whereas proactive resilience means accepting the inevitability of change and fostering the capacity of adapting to new conditions and imperatives. The latter is very similar to the definition of proactive adaptation, which is why Dovers and Handmer (1992) link resilience to planning for and adapting to hazards. Developing the concept further in a later paper, they present a three-class typology of institutional resilience distinguishing Type 1 Resilience as 'resistance to change/maintenance', Type 2 Resilience as 'change at the margins' and Type 3 Resilience as 'openness and adaptability' (Handmer and Dovers 1996). Arguing that current institutions and policy processes appear to be locked into the 'Type 2 Resilience', characterized by change at the margins or only 'fine tuning', they state that this type of resilience *'is possibly the most dangerous path: a relieve valve that gives the appearance of change and alleviates symptoms for a time'* (ibid.: 506). Therefore, Type 3 Resilience, comprising flexibility and readiness to cope with uncertainty and unanticipated situations, is needed although there is a large risk that the change that had seemed necessary could turn out as maladaptive (Handmer and Dovers 1996).

So far, a lot of work on the resilience of ecosystems has focused on the capacity to absorb disturbance, also described as 'robustness' or 'resistance' according to Handmer and Dover's Type 1 Resilience. But it has also been used in relation to social change. For instance, Adger (2000) investigates how social and ecological resilience are related and defines social resilience as analogous to *'the ability of* [human] *communities to withstand external shocks or pertubations to their infrastructure'* (Adger 2000: 361). But as already mentioned, resilience is not only about being persistent or robust to disturbance. And applying the concept of resilience either to social domains only or to ecological domains only seems to fall short. That is why the work on resilience put forward by the Resilience Alliance[8] focuses on linked socio-ecological systems and incorporates the idea of adaptation, learning and self-organization, in addition to the general ability to persist disturbance. The latter understanding is similar to Handmer and Dover's Type 3 Resilience. The Resilience Alliance's comprehensive interpretation thus considers three characteristics of resilience (1) the amount of change the system can undergo and still retain the same controls on function and structure, (2) the degree to which the system is capable of self-organization, (3) the ability to build and increase the capacity for learning and adaptation.

The conceptual links between resilience and adaptive capacity are obvious, but the connection between the two concepts and other related concepts like, for example, vulnerability, remains unclear because of the diversity of views and the different intellectual approaches of the distinct scientific communities (see Gallopín 2006). Whereas Carpenter et al. 2001 consider adaptive capacity to be a component of resilience, Pelling (2003) sees resilience as a determinant of vulnerability being close to the IPCC's interpretation of

[8] The Resilience Alliance was established in 1999 as an international research network of scientists from many disciplines who collaborate to explore the dynamics of socio-ecological systems. The purpose of the Resilience Alliance is to stimulate interdisciplinary and integrative academic research on resilience and to support international policy processes on global change and sustainable development. For example, a scientific background paper on resilience and vulnerability for the World Summit on Sustainable Development 2002 in Johannesburg, South Africa, was prepared by the Resilience Alliance (Folke et al. 2002).

adaptive capacity (McCarthy et al. 2001) with his understanding of resilience. Folke et al. (2002) refer to resilience as an antonym or the 'flip side' of vulnerability and Adger (2006) similarly argues vulnerability to be resilience portrayed in negative terms. Attempts to illuminate the conceptual interlinkages (i.e. Berkes 2007; Gallopín 2006; Schoon 2005) lead to different recommendations for the interpretation and usage of the concepts and close with many open questions. However, following Gallopín (2006) and Klein et al. (2003), vulnerability does not appear to be the opposite of resilience as vulnerability comprises the external factors of exposure and sensitivity. Resilience then would appear to be an internal property of the system obviously related to the concept of adaptive capacity.

For the purpose of this paper, it seems to be applicable to see resilience as *'both the capacity of a system to react appropriately to moments of crises that have not been entirely anticipated, and its ability to anticipate these crises and to enact, through planning and recovery'* (Aguirre 2006: 1). Resilience then implies three qualities, these being *'resistance'*, *'recovery'* and *'creativity'*. A highly resilient system is able to show all three properties of resilience (Weick and Sutcliffe 2007).

The first property *'resistance'* is the capacity of a system to withstand disturbances and their consequences. Analogous to the ecological 'buffer capacity', it can be regarded as the degree of disruption that can be absorbed or buffered without the system changing significantly its function or structure. Figure 1a shows this ability as the distance between the pre-disruption level of functioning and a threshold beyond which the system would be unable to return to its usual state of function or structure. The wider the distance between the original level of functioning and the threshold, the higher the resistance and the more disruption would be needed to push a system beyond the threshold.

The second property *'recovery'* relates to the concept of 'coping capacity'. It describes the ability of a system to pull through the time of disturbance and to 'bounce back' to the pre-disruption level of functioning as shown in Fig. 1b. It can be measured by the speed of recovery and is often denoted as 'engineering resilience' (Folke 2006). Referring to this property, a system returns the quicker to its original state the more resilient it is.

As third property, *'creativity'* describes the ability of a system to advance by adapting to new circumstances. The system therefore does not only recover to its initial level of functioning but attains a higher level of functioning (compare Figs. 1c, 2). This third property of resilience is clearly linked to 'adaptive capacity'. Thus, a high resilient system enhances its functioning by learning from experience and improving its capacity for adjusting to new conditions.

Ideally, these three properties of resilience are additional, i.e. each can evolve at any time, and all properties can be applied in combination. But in reality, it is more likely that

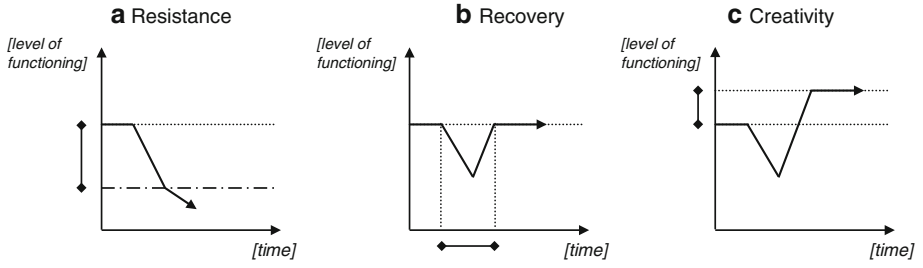

Fig. 2 Three properties of resilience (from Maguire and Hagan 2007)

the formation of these properties follows a kind of development path meaning they are evolutionary.

Applying the concept of resilience to the case studies shows how these three regions strengthen the components' resistance, recovery and creativity in certain fields of action. To give one concrete example, one of the projects discussed a new strategy to handle the increasing risk of mudslides in villages due to intense rainfalls. As a first point, quite simple mobile barriers for a better direction of the mudslide have been introduced. These barriers can be quickly applied and avoid the intrusion of mud into buildings (improved resistance). As the barriers channel the effluent, the phase of rehabilitation can be shortened (combined with a better organization of the emergency management this means a higher rate of recovery). And finally creativity has been shown by introducing precautionary measures such as thresholds or raised kerbstones and doorways or enclosures of basement windows. Whereas the latter could also be considered as a measure to improve resistance at the object level (a single building), it means creativity at town level with letting the water in and finding ways to deal with it without damage. Another example can be given in relation to floodings. All three case study regions face the increasing risk of floods both at rivers and at streams. The presence of natural retention areas, polder regions and the existing system of dikes for example determines the region's resistance against floodings. To increase resilience related to resistance the regions therefore have to preserve or expand their retension areas, polders and dikes. In relation to recovery, again a better organization of the emergency management by e.g. improved cooperation between the different local and regional authorities helps in case a river actually bursts its banks. Finally, one of the case study projects also developed and promoted manifold individual precautional flood protection measures like to tile basement walls or to zone the building distinguishing parts that could be flooded with minor damages from parts that should not be flooded. On the one hand, these examples can be understood as measures to enhance individual resistance. On the other hand, they also represent creative measures in terms of the third property of resilience as they show a paradigm shift in accepting the increasing risk of flooding and showing ways to handle the situation.

Overall, it can be stated that the processes of drafting regional adaptation strategies stimulate many activities leading to an improvement of the above-mentioned three properties of resilience. Often, the developed adaptation measures only meet one or two of them, but sometimes all three qualities are addressed. If regional adaptation strategies like the ones described within this paper increase learning and self-organization, they can make a significant contribution to a region's resilience and help to overcome the three deficits of knowledge and information, motivation and implementation. Creativity and the ability to learn as a third component of the concept of resilience are furthermore of importance as this adaptive and creative learning does not only imply learning based on experience. In the context of climate change adaptation, this is highly relevant as *'personal experience with noticeable and serious consequences of global warming is still rare in many regions of the world'* (Weber 2006:104); therefore, it would be misleading only focusing on experience. The case study regions thus do right in trying to *'evoke visceral reactions towards the risk of global warming'* (ibid.:103) by estimating and simulating possible future consequences of climate change for the region's landscapes, settlements and economy. According to the concept of resilience, this means not only thinking and acting related to specific events (e.g. extreme weather events that are likely to increase) but also focusing on adaptive capacity towards gradual changes (like the long-term changes of temperature and precipitation patterns). Comprising buffer capacity within the component 'resistance', coping capacity within the component 'recovery' *and* adaptive capacity within the component

'creativity' the concept of resilience offers a holistic view of the regions' abilities to act under changing circumstances. Hence, resilience thinking equates to an institutional approach to climate change adaptation, 'looking for constraints in the gaining of knowledge about climate change effects, vulnerabilities and opportunities and in acting on that knowledge. Adaptive capacity would accordingly be constrained by limited capacity to learn and capacity to act, reflecting the parallel organizational systems of 'thought and idea' and 'action' (Inderberg and Eikeland 2009: 435f).

So far, an increased awareness for the issues of climate change adaptation can be stated in the case study regions. Also, first measures have been realized and the stakeholder networks are vital and committed. The projects indeed contribute to overcome the three mentioned deficits of knowledge and information, motivation, and implementation. But they also reveal that regional adaptation strategies that are developed in this way cannot absolutely cover the whole region and all potentially affected sectors. Bottom-up stakeholder networks like implemented in the case study regions have to be understood as proposal for participation. If relevant stakeholders cannot be convinced to be part of the network their interest, concerns and adequate adaptation options may not become part of the adaptation strategy. Albeit the network approach allows a holistic and integrated perspective on the regional adaptation strategy in development, the result strongly depends on the stakeholder commitment. Open questions regarding the future development in the regions remain:

- Will these processes have a long-term effect? Will the transfer of information and knowledge that now occurs between the actors hold on?
- Do the regional players really feel responsible for taking action within their fields of responsibility?
- Apart from the pilot projects, will their manifold adaptation options be realized?
- To what extent are other incentives (e.g. financial or regulatory incentives, emotional appeal) needed to foster realization? In that respect, will it be possible to determine a relationship between cause and effect of actions carried out in the project work and actually accomplished adaptation measures?

Furthermore, it has to be discussed how similar processes of development of regional adaptation strategies could be stimulated in other regions.

5 Conclusions

Applied to the development of regional adaptation strategies on climate change, the concept of resilience offers many insights into complex interrelations and interconnections. But it remains difficult to adapt resilience to larger spatial and/or organizational references like a region. Adaptive cycles as examined by Gunderson and Holling 2002 and Berkes et al. (2003) are more easily observed and describe regarding smaller ecological or socio-ecologic systems. The same applies to the context of business companies. The literature on the resilience of enterprises therefore also stresses adaptive cycles and learning processes (e.g. Dalziell and McManus 2004; Günther 2009). The application to a region as a complex socio-economic and socio-ecologic structure with multiple individual and collective actors and their interrelationships is only possible in a limited way. Therefore, it is perhaps utopian to believe that a whole region can become resilient. Rather parts, certain sectors or subjects, of the region can increase their distinct resilience, thereby contributing to the overall resilience of the region. Regional stakeholder networks as established in the three

case study regions can make a significant contribution to connecting the different parts or rather sectors or subjects of a region. But they represent only one 'soft' instrument of planning. Other incentives (financial or regulatory) are also urgently needed to encourage action as recent research shows the window of opportunity for adaptation becoming smaller, making a major turnaround in policy, planning and behaviour necessary (Adger and Barnett 2009: 2800). To sum up, it can be stated that in the context of regional development, resilience can maybe only be used as comparative. Hence, different approaches can indeed lead to more resilient structures. But the resilient society at regional level remains utopia.

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