Nat. Hazards Earth Syst. Sci. Discuss., 1, 1355–1381, 2013
www.nat-hazards-earth-syst-sci-discuss.net/1/1355/2013/
doi:10.5194/nhessd-1-1355-2013
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Natural Hazards and Earth System Sciences
Open Access
Discussions

This discussion paper is/has been under review for the journal Natural Hazards and Earth System Sciences (NHESS). Please refer to the corresponding final paper in NHESS if available.

Social capacities for drought risk management in Switzerland

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Received: 22 January 2013 – Accepted: 2 April 2013 – Published: 17 April 2013

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Published by Copernicus Publications on behalf of the European Geosciences Union.

Abstract

This paper analyses the social capacities for drought risk management and gaps from the perspective of national and regional water users and policy and decision makers in Switzerland. The analysis follows five dimensions of social capacities as prerequisites for drought risk management. Regarding information and knowledge (1), basic data is available, however not assembled for an integrated drought information system. As to technology and infrastructure (2), little pro-active capacities are available with exception to few drought-prone regions; in emergency response to drought though, provisional capacities are put together. Regarding organisation and management (3) most regions have enough personnel and effective cooperation in case of acute drought; long-term strategies though are largely missing. Economic resources (4) have been considered as sufficient if drought remains rare. Finally, institutions and policies (5) are not sufficient for pro-active drought risk management, but have been suitable in the drought of 2003. Starting points for building social capacities are first to draw back upon the extensive experiences with the management of other natural hazards, second to build an integrated drought information system, including social and economic impacts and third to improve the institutional framework through consistent regulations and coordination for pro-active drought risk management.

1 Introduction

Droughts are complex hydro-meteorological phenomena and mostly related to the decrease in the amount of precipitation over an extended period of time (Mishra and Singh, 2010; Tate and Gustard, 2000; van Lanen and Peters, 2000). The general climatic conditions within a particular region as well as local influences such as altitude and basin size influence the spatial occurrence, duration and severity of droughts. Thus, there is no universal definition of droughts (Bradford, 2000; Mishra and Singh, 2010). Droughts and low flow situations can result in a slow onset hazard that develops

NHESSD

1, 1355–1381, 2013

over time. Its impacts are diffuse and spread slowly, in contrast to other rapid onset natural hazards, such as floods, earthquakes and landslides. Droughts affect certain areas in Europe almost every year, mostly in the Mediterranean (e.g. Spain, France, Italy) and Central and Eastern Europe (e.g. Hungary, Bulgaria, Russia) (Bradford, 2000).

In Switzerland, known as the water tower of Europe (EEA, 2009), droughts have been rare in the 20th century. Droughts only occurred in the years 1947, 1949, 1976 and 2003 while more frequent in earlier centuries (Pfister and Rutishauser, 2000). Thus, opposed to other European countries, e.g. Spain, France and Italy, Switzerland has not established a national approach of integrated drought risk management including all phases from pro-active mitigation, preparedness and early recognition, to re-active impact assessment, response and recovery (Vogt and Somma, 2000). Yet, Switzerland has some regions which have suffered drought effects regularly since centuries and have established mitigation systems, e.g. the centuries-old irrigation systems (Suones) in the Valais (Rodewald and Knoepfel, 2011) or the effective fire prevention management system in the Ticino (Pezzatti et al., 2013).

In Switzerland, similar to other affected countries in Europe, the 2003 drought event stands out as a “climatic surprise” (Beniston and Stephenson, 2004). Extremely high temperatures and periods of low precipitation resulted in droughts and heat waves that affected many regions in Switzerland that had not experienced droughts for a long time (ibid.). The 2003 drought event had severe impacts on both the environment (e.g. significantly lower discharge in many rivers; rapid mass losses of mountain glaciers; unusually high amounts of slope instability events) and on socio-economic systems (heat-related health problems and mortality, economic losses for the agricultural sector and the energy sector) (BUWAL et al., 2004; ProClim, 2005; Fuhrer et al., 2006; Beniston, 2007). Public authorities, politicians and the different water users, such as farmers, shipping operators, hydropower companies, health services and forest fire services, were surprised by the severity of the drought event and by its impacts.

As a consequence, since 2003 drought risks have been on the agenda of both national and regional policy and decision makers as well as private water users in

NHESSD
1, 1355–1381, 2013

Switzerland. Political initiatives have been launched to strengthen drought risk management (e.g. BAFU, 2012a, b). Also many public and private actors and water users (e.g. farmers, municipalities, water and energy supplier) got concerned about drought risks and are currently preparing strategies how to deal with future drought events (cf. Karrer, 2012; BLW, 2011; Collet and Niederhäusern, 2008). However, establishing effective drought risk management, understood as a process to avoid, lessen or transfer the adverse effects of drought hazards in Switzerland is a long-term process that involves a set of social capacities, i.e. the abilities, skills and internal resources to successfully anticipate and respond to hazard events and their impacts (Kuhlicke et al., 2011).

The aim of the paper is to provide a structured analysis of the social capacities for drought risk management in Switzerland as well as gaps from the perspective of water users and policy and decision makers on the national and cantonal level. With this analysis we aim at identifying starting points for building social capacities for drought risk management. The research questions guiding the investigation presented here are:

- What social capacities do exist so far for drought risk management in Switzerland from the perspective of water users and policy and decision makers?
- What social capacities for drought risk management in Switzerland are perceived as missing?

The analysis is based on data from the two research projects: "Early recognition of critical drought and low-flow conditions in Switzerland" (Funding: Swiss National Science Foundation) and "Fostering European Drought Research and Science-Policy Interfacing" (Funding: EU FP7). Data was collected in standardised surveys, in expert interviews and in stakeholder workshops with policy and decision makers and water users with a focus on drought risk mitigation and response measures and a focus on the institutional and policy context supporting drought risk management.

NHESSD
1, 1355–1381, 2013

The paper is structured as follows: first we sketch a conceptual framework for the investigation of social capacities for drought risk management (Sect. 2) which we apply for the analysis and presentation of the results. After describing the methods used for the study of drought risk management in Switzerland (Sect. 3) we present the results differentiating between social capacities for pro-active and re-active drought risk management (Sect. 4). In Sect. 5 we discuss the social capacities for drought risk management in Switzerland focussing the implications for capacity building, the limitations and the transferability of results and conclude the paper with Sect. 6.

2 Conceptual framework: investigating social capacities for drought risk management

According to the United Nations Office for Disaster Risk Reduction (UN-ISDR), drought risk management is the concept and practice to avoid, lessen or transfer the adverse effects of drought hazards and the potential impacts of disaster through activities and measures for mitigation, preparedness, response and recovery (UN-ISDR, 2009). Scholars draft drought risk management as a continuous process following the disaster management cycle with pro-active strategic measures in preparation for future drought events and with re-active emergency measures in the onset of a drought (cf. Fig. 1; Rossi, 2000; Wilhite et al., 2000; Kampragou et al., 2011). Following the disaster management cycle, pro-active drought risk management includes implementing mitigation activities, increasing preparedness for future drought events and establishing and improving an early recognition system for drought events. Re-active drought risk management involves conducting an impact assessment during and after a drought event, realising response measures in the affected areas and accomplish recovery from drought damages. The phases of the drought risk management cycle do not necessarily occur in the linear way the cycle suggests. For example early recognition of a drought event and impact assessment may merge if an integrated drought information and warning system exists; the implementation of measures for recovery from drought

NHESSD
1, 1355–1381, 2013

events (e.g. artificial ground water recharge; reforestation of an area affected by forest fire) may need years, during which mitigation and preparedness (e.g. investment in water infrastructure; establishing forest fire emergency services) is strengthened simultaneously.

The presence of social capacities is a necessary condition for realising pro-active and re-active drought risk management activities. In natural hazard management, social capacities refer to the abilities, skills and internal resources of an individual, group or organisation to successfully anticipate and respond to external stressors, i.e. the natural hazard events and their impacts (Kuhlicke et al., 2011; Höppner et al., 2012). Drawing on different strands of literature from vulnerability studies, climate adaptation sciences and social-ecological resilience research, social capacities can be grouped along different dimensions (Brooks et al., 2005; Armitage and Plummer, 2010; Gupta et al., 2010; Keskitalo et al, 2011; Engle, 2011). For our study on social capacities of drought risk management in Switzerland, we will build upon a systematisation of adaptive capacities elaborated in the fourth assessment report by the Intergovernmental Panel on Climate Change (IPCC) including five dimensions: knowledge and information, technology and infrastructure, economic resources, organisation and management as well as policies and institutions (Adger et al., 2007). The concept of adaptive capacity, understood as the ability or potential of a system to respond successfully to climate variability and change, resembles the understanding of social capacities in natural hazard management, with the advantage that it has been applied and specified in a large number of studies (among others Yohe and Tol, 2002; Smit and Wandel, 2006; Engle and Lemos, 2010; Glaas et al., 2010). Preston et al. (2011) emphasise that the dimensions of adaptive capacities need to be specified according to the specific context of the analysis, in our case to drought risk management. Therefore we assume that drought risk management involves a set of specific capacities that can be grouped along these five dimensions.

So far, there has been some empirical research on social capacities for drought risk management, mostly in areas highly affected by drought risks, i.e. in Africa, Australia,

NHESSD
1, 1355–1381, 2013

the United States and the Mediterranean region. These studies exemplify what are possible social capacities for drought risk management (cf. Table 1). For instance, a study on drought risk management in Africa emphasises the need of drought information tools for effective pro-active drought risk management (Vincente-Serrano et al., 2012). A case study in Ethiopia came to the conclusion that professional training of farmers and changes in agricultural practices, e.g. soil and water conservation practices are key capacities to adapt to and cope with droughts (Murendo et al., 2011). In a comparative study of three rural communities in the Canadian prairie Wittrock et al. (2011) identified water supply infrastructure and a diversified income base as the most important capacities for decreasing the vulnerability to droughts. In their investigation of drought risk management in Australia Nelson et al. (2008) stress the need for drought policies capable of integrating local knowledge and institutions that enable the management of water as a common property resource (e.g. catchment management authorities). Iglesias et al. (2011) stress the need for socially and economically sensitive policies in order to prevent inequalities in the view of climate change in the Mediterranean region.

In our study we will investigate what social capacities do exist or are missing for drought risk management in Switzerland. We use the the framework depicted in Fig. 1 for leading the study and presenting the results.

3 Methods

The results presented in this paper are based on two studies conducted between 2010 and 2012. In the first study we investigated social capacities from the perspective of water users with a focus on drought risk mitigation and response measures, and proceeded in two steps. In a first step we administered a survey questionnaire to fifteen representatives of water user groups (return rate: 66 %). We asked which measures they realise to mitigate or reduce drought induced damage, which information they use and which further information they would need for realising those measures. The survey questionnaire was designed to prepare an expert workshop with thirteen

NHESSD
1, 1355–1381, 2013

representatives of the different water user groups where we discussed and specified the results. In a second step we investigated the effectiveness of different pro-active and re-active measures for the reduction of drought risks by conducting nine qualitative interviews with representatives from three economic sectors affected by droughts: agriculture (focusing on irrigation in fruit growing), forestry (focusing on prevention of forest fire), and the energy sector (focusing on hydro power production). Here, we were interested in the interviewees' perception and evaluation of applied or potential drought risk measures.

In the second study we investigated the social capacities for drought risk management with a focus on the institutional and policy context supporting drought risk management. We conducted nine expert interviews and administered a questionnaire survey to 32 representatives of cantonal authorities for environment, national agencies and associations as well as applied sciences (return rate: 44 %). The drought event of 2003 served as a reference event and a set of questions focussed on the participants' perception of the changes in drought risk management and lessons learned after the experiences of 2003.

For both studies we chose an explorative and qualitative research design because of two reasons: first droughts and drought risk management is a rather new approach in Switzerland; and second, there is not a large population of water users and relevant policy and decision makers of national and cantonal level. Thus, we conducted interviews and surveys with representatives of water user groups from different economic sectors potentially sensitive to droughts: agriculture (considering farming, vegetable growing, fruit growing), forestry, water supply, shipping industry, fishery and tourism. For the sample, we considered experts from national or regional associations, private companies, public administration, civil society and applied sciences as well as from all regions in Switzerland (Northwest-, East- and Central-Switzerland, French-speaking Switzerland and Ticino). The workshop and the interviews were recorded in writing and partly audio-recorded and transcribed. Together with the open questions of the survey questionnaire, the data was analysed according to methods of qualitative content analysis,

NHESSD
1, 1355–1381, 2013

i.e. inductive formulation of categories, coding of the text along the categories, qualitative analysis and interpretation of results (Mayring, 2010). For answering the research questions all data was considered.

4 Results

The survey and interview studies with different water user groups in three economic sectors showed that water users have a range of existing mitigation and response measures at hand that they realise in case of droughts and low flow conditions. These measures are specific for each water user group and can be structured along the dimensions of social capacities (cf. Table 2). For realising these measures, the existence of social capacities is a prerequisite. In summary, the results show that the survey participants and interviewees consider the capacities for re-active crisis management overall as rather sufficient, but see some deficits in pro-active strategic drought management. In what follows, we present the results with regard to the framework introduced in Sect. 2, along the five dimensions of social capacities for pro-active drought management (cf. Sect. 4.1) and re-active drought risk management (cf. Sect. 4.2).

4.1 Social capacities for pro-active drought risk management in Switzerland

The results on the existing and missing social capacities for pro-active drought risk management in Switzerland from perspective of the water users and policy makers are summarised in Table 3. Concerning the first dimension “information and knowledge”, the surveys and interviews show that drought information is considered as an important basis for pro-active drought risk management. Monitoring and information systems for different meteorological and hydrological variables (for example precipitation, air temperature, ground water level, surface water level, run off, snow water equivalent) are available in Switzerland, although they are not yet accessible in an integrated drought information system for the water users. The survey and workshop showed that this

NHESSD
1, 1355–1381, 2013

drought information system would need to include a large set of drought variables if it shall satisfy the information requirements of the different water user groups (Kruse et al., 2010). Furthermore, the different water user groups require not only specific drought variables, they also have different needs concerning the prediction period, the spatial resolution of drought information and the accuracy of predictions (cf. Table 4). Also, monitoring of water availability, water usage and water distribution is not established as a standard procedure in the municipalities and cantons. Another challenge for pro-active drought management is the transfer of drought information into drought mitigation activities. Some interviewees stress that there is still a low problem awareness concerning droughts impacts in Switzerland. Until droughts do not occur more often, seemingly many water users react as follows: "One cannot do much about it. If it is dry, it is just dry." (Interviewee from a Swiss water association).

Establishing technical infrastructure for drought risk management (e.g. irrigation systems, water storage capacity, water infrastructure for fire fighting), the second dimension of social capacities, is an important prerequisite of pro-active drought management. It demands long-term planning which needs to be embedded in strategic management decisions. The interviewees stress that for investments on technical infrastructure they need robust information about future development of drought risks. This is in many aspects still a challenge for climate sciences, though many studies predict an increase of droughts in some parts of Switzerland (Rebetez, 1999; Beinston and Stephenson, 2004; Reinhard et al., 2005). Additionally, it may also be that some water users have a disbelief in these studies as long as droughts do not occur more often.

Also organisation and management, the third dimension of social capacities, are important for pro-active drought risk management, especially concerning the diversification of products, branches of industry and sites, e.g. in agriculture and hydropower production. In general, the more diverse a production the less vulnerable the business is to drought situations. The interviews revealed that for now, diversification is not realised primarily due to drought risks but due to general management risks of the business. Hence, many measures in the field of organisation and management have

NHESSD
1, 1355–1381, 2013

synergies with other goals of a farm or company. Thus, drought risk management is ideally embedded in the overall management strategies.

According to the interviewees the economic resources, the fourth dimension for pro-active drought management, seem to be sufficient. Nevertheless, this has to be seen in the context that so far pro-active drought risk management has not been a priority to water user groups and only few high cost investments have been made so far; for example setting up a forest fire monitoring system in Switzerland is still in the pilot phase.

Regarding the fifth dimension, policies and institutions, many interviewees criticise that up to now a coherent integrated drought risk management and strategy for dealing with water scarcity is missing. The regulations governing the usage and withdrawal of water in times of water scarcity resemble – following an interviewee – a "rag rug" rather than a coherent institutional framework (Interviewee from a network of Swiss water supply and distribution companies). Many interviewees see the main barriers for developing an institutional framework for drought risk management that goes beyond emergency and crisis management in the federal and subsidiary system of water relevant regulations. The withdrawal of water is governed by the canton or by the communities in case of temporary water withdrawal facilities. Up to now, there are no nation-wide comprehensive guidelines for the approval of water withdrawal, for prioritising certain water users or for monitoring the amount of water withdrawal. During past droughts, this has led to conflicts between different water user groups and across municipal and cantonal boundaries within a watershed. At the same time natural hazard management (e.g. flood management) as well as water management (e.g. integrated watershed management) in Switzerland can build upon a long tradition and experience in inter-cantonal cooperation which is constantly strengthened by new initiatives, e.g. the inter-cantonal early warning and crisis information system (IFKIS) and the resolution for optimisation of warning and alerting (OWARNA). Some interviewees believe that as soon as droughts will occur more often and public attention will rise, policies and regulations for drought risk management will be established and integrated in the existing institutional

NHESSD
1, 1355–1381, 2013

frame of natural hazard management. The initiative of a parliamentarian to develop a strategy for the management of local water scarcity in Switzerland, prompted by the drought event of 2003 and the resulting report on this initiative supports this estimation (BAFU, 2012b).

4.2 Social capacities for re-active drought risk management in Switzerland

The results on the existing and missing social capacities for re-active drought risk management in Switzerland from the perspective of the water users and policy makers are summarised in Table 4. Concerning the first dimension "information and knowledge" the survey and workshop showed that an integrated drought information system including both hydro-meteorological drought variables and social and economic impact variables is currently missing in Switzerland, but would be one of the most important prerequisites for effective drought impact assessment. This is one of the measures planned to be implemented in a strategy for dealing with water scarcity currently developed by the Federal Office for the Environment (BAFU, 2012b). Yet, the survey among cantonal environmental agencies revealed that monitoring of economic and social impacts of droughts is still an exception. When it comes to knowledge, the investigation of the drought mitigation measures shows that not only information but also the local knowledge about impacts of experts familiar with the respective sites and local conditions, e.g. farmers, hydropower operators or foresters, is important for evaluating the drought impacts and arranging corresponding response measures (cf. Table 2).

The technological and infrastructural capacities for re-active drought response in Switzerland, the second dimension, have been rather limited so far. During the drought event in 2003, mobile irrigation was supported by water tankers provided by the army and local fire brigades. In a region of the Valais that was not sufficiently equipped for forest fire extinction, a fire expanded and caused massive damages and following costs for the recovery (Moretti and Conedera, 2003).

Concerning organisation and management, the third dimension, in the respondents' opinion the extreme drought event in 2003 demonstrated that there were enough

NHESSD
1, 1355–1381, 2013

personnel to organise and manage emergency and drought defence measures (e.g. irrigation of crops, distribution of drinking water, emergency service for forest fire). In some parts of Switzerland the army and community services supported farmers with irrigating the crops. Other than on the national and cantonal level, on the local level there was not enough personnel for nominating a drought delegate in most of the affected communities. Consequently, local officers had to work overtime to coordinate drought defence measures, but as one interviewee puts it: "[. . .] people have a high motivation, especially in this kind of situations. Therefore, it always has worked so far.". The cooperation between the cantons, the involvement of national and regional associations (e.g. farmers associations) and solidarity among farmers and the population was evaluated positively.

According to the interview study the fourth dimension, the economic capacities and financial means available for crisis management in reaction to drought events are considered sufficient, as an interviewee from an authority for agriculture states "If there is a drought event, one changes his priorities [. . .] and authorises the resources", at least as long as droughts remain a rare phenomenon.

Also regarding the dimension of institutions and policies the survey participants and interviewees evaluate the capacities as sufficient. Emergency measures have been implemented in a flexible way also across administrative boarders. The high state of regulations for emergency response in natural hazard management in general might have supported the response to droughts in 2003.

5 Discussion: implications for building capacities for drought risk management in Switzerland

The results show that from the perspective of water users and decision makers the situation of social capacities is as follows: to support a proactive drought risk management information and knowledge as well as economic resources are mostly available, while regarding technology and infrastructure as well as organisation and management

NHESSD
1, 1355–1381, 2013

long-term strategies are still needed. The institutional framework for pro-active management is fragmented, and an integration of drought risk management in existing hazard management policies and institutions is perceived as promising.

For re-active drought risk management the picture is more positive as the water users and decision makers perceive that technology, infrastructure, personnel and economic resources are sufficiently available to cope with emergency and crisis situations. Only concerning information and knowledge, an integrated drought information system is considered as necessary in order to enable monitoring not only of the drought situation but also of social and economic impacts.

Thus overall, the results depict a moderate state of social capacities regarding drought risk management and, hence, an early stage in pro-active and re-active drought management in Switzerland. The various sources we used are consistent regarding this conclusion. This conclusion is not surprising for two reasons: first, drought is not (yet) a pressing problem but rather a rare natural hazard in Switzerland. This also explains why the survey participants and interviewees consider today's infrastructure, economic resources and organisational and management capacities as sufficient. Yet, these capacities would need to be extended in case of more frequent droughts. Second, Switzerland has a long-standing tradition in integrated risk management of natural hazards (especially floods, mudflows, avalanches, rockslides etc.) on which the evolving drought risk management draws upon. Hence, in crisis situations some re-active drought risk measures can easily and quickly be established as it was the case in the drought event in 2003. At the same time, the water users and policy and decision makers express some alertness regarding the need to develop specific strategies for managing drought risks. Especially, public agencies recognised the need and have recently developed a rough strategy how to deal with water scarcity on the national level in Switzerland (including measures for exceptional situations and for long-term provision, BAFU, 2012b, p. 10). This strategy is planned to be followed by various activities such as the identification of drought risk areas, management plans for water resources

NHESSD
1, 1355–1381, 2013

in drought risk areas and the development of a code of practice with examples on how to settle conflicts on water issues (BAFU, 2012b, p. 7ff).

Regarding the implications for building social capacities we conclude that urgency due to looming drought events is an important ingredient. The results suggest that the process of building social capacities may be accelerated through drawing back upon capacities already existing in related fields (i.e. natural hazard risk management), upon experience from single cantons (e.g. fire risk management in Ticino), through taking notice of research – ideally of scientists of the own country – and through raising awareness of historical events and management strategies such as the Suones (traditional water channels for irrigation) or the common property management of water resources which is still alive in the neighbouring Vinschgau (Italy). Most important is a national coordination and framework that spurs cantons and municipalities to carry out their duties, avoids duplication and places importance on drought risk.

In our research we analysed the perception of drought risk management in Switzerland by water users and policy and decision makers. The evaluation of the capacities from their perspective needs to be seen within the individual context the respondents draw upon. This context may be the drought risk situation and management which varies among the regions and cantons – and the level of nationwide natural hazard risk management – which is quite high in general. For example in the fire-prone canton of Ticino social capacities regarding forest fires are highly developed. Since the 1990ies and following legislative, technical and organisational measures, damages from forest fires and the amount of burnt area have decreased, even during 2003 (Pezatti et al., 2013). In other regions forest fires are rather uncommon and both policies and regulations as well as technical and organisational measures are poorly developed. Hence, a contradictory and broad appraisal of the situation is not surprising.

The methods we used allow both, an overview and a substantial insight into the topic. A problem of an investigation that concerns the Swiss-wide situation is the variety in cantonal and local contexts both regarding drought risks and their management. An investigation of each of the 26 cantons, however, is very time-consuming and may –

NHESSD
1, 1355–1381, 2013

for an overview – not be worth the effort. Furthermore, we only got limited information regarding the drought management in 2003 as either people do not remember or are retired.

6 Conclusions

In order to build up and realize an integrated drought risk management in Switzerland social capacities need to be enhanced and developed. Although, valuable preconditions regarding the five dimensions of social capacities are available, we see particular need to assemble the available data in an integrated information system, to expand technologies and infrastructure for pro-active capacities, not to dwell on hitherto successful ad-hoc management but to develop long-term strategies, to be ready to expand financial resources and to coordinate better institutions and policies which so far fragmented.

Though Switzerland definitely is not at the top of drought risk management compared to countries such as Spain, Italy, or even the Netherlands (Ministry of Infrastructure and the Environment, 2012), and though Switzerland is constitutionally in a particular institutional and cultural situation, the results may be of interest for other developed countries which are confronted with increasing drought risks. Useful for building social capacities for drought risk management seems to draw back upon other natural hazard risk management frameworks and experience, to use existing relevant data and to invest in monitoring the missing data, including social and economic impacts, to give importance to regional and local knowledge and experience and finally to overcome an institutional rag rug through consistent regulations and coordination.

Acknowledgements. The research presented in this paper has been conducted within the project “Early recognition of critical drought conditions in Switzerland: coping with shortages in soil moisture, groundwater and runoff” funded by the Swiss National Science Foundation (SNF) (No. 125925) and the project ”Fostering European Drought Research and Science-Policy Interfacing” funded by the European Commission under the FP7 Cooperation Work Programme

NHESSD

1, 1355–1381, 2013

2011 (Grant agreement no. 282769). The authors are most grateful to the survey participants and interviewees that took part in the two studies.

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NHESSD

1, 1355–1381, 2013

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NHESSD
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NHESSD
1, 1355–1381, 2013

Table 1. General social capacities for drought risk management (own design).

Social capacity dimensions	Examples for general social capacities for drought risk management
1. Information and knowledge	– early recognition and drought information tools; education and training of farmers; problem awareness (Vincente-Serrano et al., 2012)
2. Technology and infrastructure	– water supply infrastructure; irrigation systems; fire fighting equipment (Wittrock et al., 2011)
3. Organisation and management	– adapting soil and water conservation practices (Murendo et al., 2011)
4. Economic resources	– diversified income, insurances (Wittrock et al., 2011)
5. Policies and institutions	– national/regional drought policies, regulations for water distribution; concessions for water withdrawal; catchment management authority (Nelson et al., 2008; Iglesias et al., 2011)

NHESSD
1, 1355–1381, 2013

Table 2. Overview on existing and missing pro-active and re-active drought risk measures in three selected water user groups in Switzerland (own design).

Social capacity dimensions	Drought risk measures per water user group		
	Agriculture (Fruit-growing)	Energy production (Hydropower)	Forestry (Forest fire prevention)
Information and knowledge	Monitoring of precipitation and soil moisture on the site; public weather services[2]	Forecasting of run off and precipitation[2]	Daily drought maps in some Cantons, processing weather forecast and local knowledge[2]
Technology and infrastructure	Irrigation systems[1]	Increase of pump storage capacity[1]	Water infrastructure for fire-fighting[1]
Organisation and management	Soil treatment[2] Diversification of crops[1]	Management of turbine operation[2] Regional/operational diversification[1]	Stand-by for emergency response duties (helicopter)[2] Management of burnt material[2] Long term risk evaluation[1]
Economic measures	No specific drought insurances in use[2]	Hedging of risks[2] No specific drought insurances in use[2]	No insurances anymore, instead regional funds for firefighting[1]
Policies and institutions	Subsidies for irrigation[1]	Concessions for hydropower production[1]	Fire bans (permanent/temporary)[2], federal regulation for warning[1]

[1] pro-active measures in direct response to droughts
[2] re-active mitigation measures

NHESSD
1, 1355–1381, 2013

Table 3. State of social capacities for pro-active drought risk management in Switzerland (own design).

Social capacity dimensions	Pro-active drought risk management
Information and knowledge	– Broad set of information available but not integrated in a drought information system – Low drought risk awareness
Technology and infrastructure	– Long-term strategies needed for investments in technology and infrastructure for increasing mitigation and preparedness
Organisation and management	– Long-term strategies needed for organisational and management options
Economic resources	– Sufficient resources available (under the premise of rare intervals of drought events)
Policies and institutions	– Institutional framework for mitigation and preparedness is fragmented; some potential is seen in the integration of droughts in existing natural hazard and water management policies and institutions

NHESSD
1, 1355–1381, 2013

Table 4. Variables for the early recognition of droughts from the perspective of user groups and availability of information (Kruse et al., 2010).

Variables from perspective of water user	Relevant for the following user groups/stakeholders	Indicator/indices/thresholds used in monitoring and prediction	Prediction period scientifically feasible	Computational time available	Spatial scale available	Accuracy of prediction available
Precipitation	Agriculture, forestry, shipping, fishery, hydropower, water management	Precipitation amount in last/next *x* days [mm]/deviation of precipitation amount in the last *x* days from long term average [%]	<10 days	Variable. 3–6 months (e.g. SPI)	Local–regional	High accuracy for <5 days; low for long term prediction
Evaporation	Agriculture	Deviation of last/next *x* days from long term seasonal average [mm]	<20 days	Variable. ca. 1 month, in summer 2–4 months	Local–national	Low dues to few measurements and dependency on many parameters
Soil moisture	Nature conservation, agriculture, forestry, BAFU	Deviation of last/next *x* days from long term seasonal average [mm]	<30 days, in some cases: <4 months	1–3 months	Local–national	Potential with SwissSMEX-data and models: high <1 month, skills <3 months
Litter moisture	Forestry	3–5 qualitative categories (very dry, dry, slightly wet, wet)	<10 days	Current situation	Local–national	N.a.
Wind speed	Forestry	n.a.	<5 days	Current situation	<40 km	High accuracy for <5 days
Water temperature	Nature conservation, fishery, energy sector	Max. temperature	<10 days	Current situation	Regional	N.a.
Ground water level	Agriculture (irrigation), water management	Deviation from long term seasonal average [m or %]	<2–3 months	from regeneration of the last year, in relation to the last 10–30 yr	Regional	High accuracy
Water level surface water	Shipping, agriculture (irrigation)	Deviation from long term seasonal average [m or %]	<15 days	Current situation	Regional	High accuracy
Run off	Nature conservation, fishery, water management, hydropower, BAFU	Q347, deviation of last *x* days from long term seasonal average [mm or $m^3 s^{-1}$]	<15 days	In relation to the last 10–30 yr	Local–national	High accuracy
Snow water equivalent	Shipping, agriculture (irrigation)	Max. value at the end of the accumulation period [mm], deviation of long term seasonal average [%].	During accumulation <10 days; during ablation <20 days	End of accumulation period	Local–national	Depends on the time of year.

NHESSD
1, 1355–1381, 2013

Table 5. State of social capacities for re-active drought risk management in Switzerland (own design).

Social capacity dimensions	Re-active drought risk management
Information and knowledge	– Integrated drought information system needed – Monitoring of social and economic impacts an exception – Local knowledge important for the risk assessment
Technology and infrastructure	– Technology and infrastructure for crisis management available but rather limited
Organisation and management	– Enough personnel available – Effective coordination and cooperation
Economic resources	– Sufficient financial means available for crisis management
Policies and institutions	– Policies and institutions for emergency measures sufficient

NHESSD
1, 1355–1381, 2013

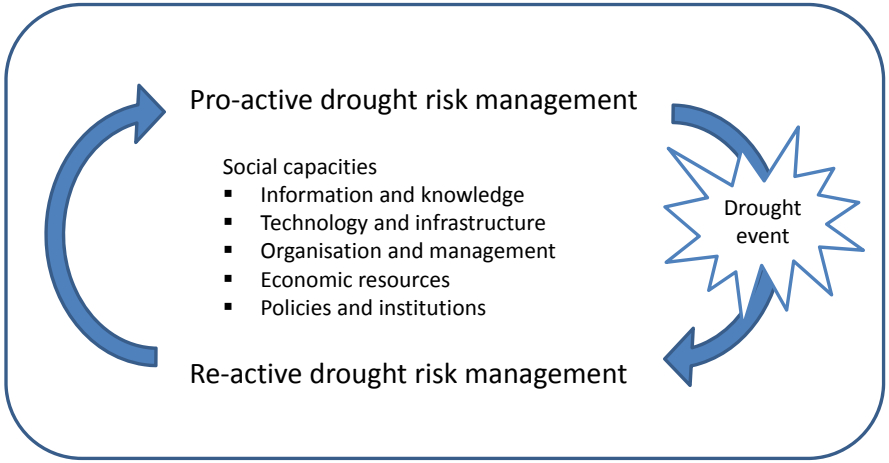

Fig. 1. Social capacities along the drought risk management cycle (own design).

NHESSD
1, 1355–1381, 2013