d·i·e

Deutsches Institut für Entwicklungspolitik

German Development Institute

Discussion Paper 6/2011

Adapting Agricultural Water Governance to Climate Change

Experience from Germany, Spain and California

Insa Theesfeld
Oscar Schmidt
Waltina Scheumann
Elke Herrfahrdt-Pähle
Chinwe Ifejika Speranza

Adapting agricultural water governance to climate change

Experience from Germany, Spain and California

Insa Theesfeld
Oscar Schmidt
Waltina Scheumann
Elke Herrfahrdt-Pähle
Chinwe Ifejika Speranza

Bonn 2011

Discussion Paper / Deutsches Institut für Entwicklungspolitik
ISSN 1860-0441

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available in the Internet at http://dnb.d-nb.de.
ISBN 978-3-88985-535-0

Elke Herrfahrdt-Pähle is a researcher at the department of environmental policy and natural resource management at the German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) in Bonn, Germany. She holds a PhD in applied system sciences of the University of Osnabrück, Germany. Her fields of study include resilience, adaptability and transformability of water governance regimes as well as integrated and adaptive water governance. E-mail: elke.herrfahrdt@die-gdi.de

Chinwe Ifejika Speranza is a geographer and holds degrees from the University of Bern (PhD), the University of Zürich (M.Sc.), and the University of Nigeria (B.Sc.). She is a researcher at the department of environmental policy and natural resource management at the German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) in Bonn. Her research currently focuses on adaptation to climate change in the agricultural sector in sub-Saharan Africa, resilience-based approaches and how such approaches can be integrated into development policy and practice. Her climate-related topics over the last 8 years include drought analysis and management for agricultural production, food security, and vulnerability assessments. E-mail: ifejika.speranza@die-gdi.de

Waltina Scheumann holds her Master in political science and a PhD in engineering. She has been a faculty member at the Chair in Environmental and Land Economics, University of Technology Berlin and a senior researcher at the Helmholtz Centre for Environmental Research (UFZ), Leipzig. She is a senior researcher at the department of environmental policy and natural resource management at the German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) in Bonn. Her work on water-related topics includes cooperation on transboundary waters, water governance issues in irrigated agriculture incl. drainage and combating salinization, and the implementation of international standards for sustainable dam development in emerging economies (Brazil, China, India, Turkey) and in developing countries. E-mail: waltina.scheumann@die-gdi.de

Oscar Schmidt holds a B.Sc. "Horticultural Science" and a M.Sc. "Integrated Natural Resource Management". He has been working as a Research Associate at the Leibniz-Institute of Agricultural Development in Central- and Eastern Europe (IAMO), Halle (Saale), and is presently a member of the Division of Resource Economics at Humboldt-Universität zu Berlin. Oscar Schmidt has worked on a variety of cases of natural resource governance in Indonesia, East-Timor, Albania and the European Union. His current regional and thematic focus is on the evolution of institutions of access to land and water resources in the context of emerging large-scale public irrigation schemes in Turkey. E-mail: oscar.schmidt@agrar.hu-berlin.de

Insa Theesfeld is an agricultural economist, specialized in institutional economics and resource economics. She received her PhD from Humboldt University of Berlin, Germany. Her research fields compose the fit between policies foreseen to be implemented and the institutional arrangements in place, the creation of institutional arrangements by communities to govern their use of renewable natural resources, the cooperation among resource users and stakeholder at different levels. Besides her strong methodological interest in institutional and policy analysis, her focus is on water resource governance. She is currently a senior researcher at the Leibniz Institute of Agricultural Development in Central and Eastern Europe, where she is leading the research focus "Institutions and Natural Resource Management". E-mail: theesfeld@iamo.de

Tulpenfeld 6, 53113 Bonn
☏ +49 (0)228 94927-0
🖷 +49 (0)228 94927-130
E-Mail: die@die-gdi.de
www.die-gdi.de

Foreword

Water is a crucial dimension in the climate change discourse, as is water governance. In agriculture, one of the most frequently cited adaptation options is irrigation. However, the modes of agricultural water governance can determine the success or failure of such adaptations. This paper thus begins by asking what we know about how river basin and water authorities in industrialised regions manage agricultural water and how they encourage adaptation to changes in water availability. How do such changes come about, what are the driving forces, and how are processes designed to stimulate adaptation organised?

This study was initiated in Department IV of the DIE, Environmental Policy and Management of Natural Resources, in the framework of the BMZ-funded flagship project on "Climate Change and Development". Dr Insa Theesfeld and Oscar Schmidt of the Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO), Halle (Saale) carried out the study in collaboration with colleagues of the DIE's Department IV.

The study provides insights into agricultural water governance in the context of climate change in three geographical areas where periodic droughts occur: Brandenburg in Germany, the Ebro Basin in Spain and California in the USA. The findings therefore offer departure points for addressing the various directions that adaptation in agricultural water governance could take in developing countries, where the socio-political contexts may be different, but the challenges of climate change have features in common. One of the next steps envisaged will therefore be to examine the implications of climate change for agricultural water governance in developing countries, with the aim of identifying likely adaptation options and paths to inducing adaptation in developing regions.

Bonn, March 2011 Chinwe Ifejika Speranza

Abstract

This study describes and discusses initiatives taken by public (water) agencies in the state of Brandenburg in Germany, the state of California in the USA and the Ebro River Basin in Spain in response to the challenges which climate change poses for the agricultural water sector. The drivers and actors and the process of changing agricultural water governance are its particular focus. The assumptions discussed are: (i) the degree of planned and anticipatory top-down implementation processes decreases if actions are more decentralized and are introduced at the regional and local level; (ii) the degree of autonomous and responsive adaptation approaches seems to grow with actions at a lower administrative level. Looking at processes of institutional change, a variety of drivers and actors are at work such as changing perceptions of predicted climate impacts; international obligations which force politicians to take action; socio-economic concerns such as the cost of not taking action; the economic interests of the private sector. Drivers are manifold and often interact and, in many cases, reforms in the sector are driven by and associated with larger reform agendas. The results of the study may serve as a starting point in assisting water agencies in developing countries with the elaboration of coping strategies for tackling climate change-induced risks related to agricultural water management.

Contents

Figures

Tables

Abbreviations

ALBERCA	Actualización de Libros de Registro y Catálogo
BAP	Basin Advisory Panel
BMU	Bundesumweltministerium – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMBF	Bundesministerium für Bildung und Forschung – Federal Ministry for Education and Research
CAT	Climate Action Team
COPI	Cost of Policy Inaction
DWR	Department of Water Resources
EAGGF	European Agricultural Guidance and Guarantee Fund
EHC	Ebro Hydrographic Confederation
EPA	Environmental Protection Agency
EU	European Union
EWMP	Efficient Water Management Practice
FENACORE	Federación Nacional de Comunidades de Regantes de España (National Federation of Irrigation Communities in Spain)
GWP	Global Water Partnership
IMA	Interministerielle Arbeitsgruppe "CO_2 Reduktion" (Interministerial Working Group on CO_2 Reduction)
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LDC	Least Developed Country
LUA	Landesumweltamt (Environmental Agency of Brandenburg)
MARM	Ministerio de Medio Ambiente y Medio Rural y Marin (Ministry of Environment, Rural and Marine Affairs)
MLUR	Ministerium für Landwirtschaft, Umweltschutz und Raumordnung (Ministry of Agriculture, Environmental Protection and Regional Planning)
MUGV	Ministerium für Umwelt, Gesundheit und Verbraucherschutz (Ministry of Environment, Health and Consumer Protection)
NAS	National Adaptation Strategy
NGO	Non-Governmental Organisation
OECC	Oficina Española de Cambio Climático
PNACC	Plan Nacional de Adaptación al Cambio Climático
RBO	River Basin Organisation
SV GUA	Sachverständigenkreis „Globale Umweltaspekte" des Bundesministeriums für Bildung und Forschung (Group of Experts on Global Environmental Aspects of the Ministry of Education and Research)
UBA	Umweltbundesamt (Federal Environment Agency)
UNFCCC	United Nations Framework Convention on Climate Change
U.S.	United States
WFD	Water Framework Directive
WSA	Water and Soil Association

Introduction

In recent years there has been growing recognition of the implications of climate change for global water resources and the agricultural sector. In many parts of the world water managers face more frequent and more intense drought and/or flood events and decreasing water availability, while water demand rises owing to improved living standards, population growth, increasing evaporation from bodies of water, evapotranspiration from plants and so on. Given this dilemma, technical innovations need to be introduced and institutional initiatives taken to ensure a sustainable supply of water in the future. In many developed countries initial steps are being taken to adapt water governance to meet this challenge, an experience from which other countries may benefit.

This study describes and discusses initiatives taken by water agencies in response to the challenges which climate change poses for the agricultural water sector and sheds light on what actually drives adaptation. By providing an overview of the measures taken in developed countries, the study seeks to contribute to the German Development Institute's conceptual discussion on how to assist water agencies in developing countries with the elaboration of coping strategies for tackling climate change-induced risks related to agricultural water management.

Agricultural water use comprises "water abstracted from surface and groundwater, and return flows (withdrawals) from irrigation for some countries, but excludes precipitation directly onto agricultural land" (OECD 2000, 48). The aim of agricultural water management is to enable farmers "to achieve high levels of irrigation efficiencies, water use efficiencies and crop productivities that will maximize return on investments in rainfed and irrigated conditions under adequate or deficit water supply" (Kassam / Smith 2001, 15). Climate change is likely to increase rainfall variability in drylands, eventually leading to increasingly variable and sometimes declining river flows, periodic water shortages, floods, water erosion, etc. Agricultural water governance can help to reduce the impacts of climate change on agricultural production.

In general, there are two approaches to coping with climate change. One is *mitigation*, i.e. "a *human intervention to reduce the sources or enhance the sinks of greenhouse gases*" (IPCC 2007a, 949). The second is *adaptation*, which refers to "*adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*" (IPCC 2007b, 869). Hitherto adaptation has received much less attention in the international debate than mitigation (Horstmann 2008). This study focuses on *adaptation*, and more specifically on *institutional* adaptation induced by national adaptation strategies, and on regional and local initiatives.[1]

Following an exploratory phase, we selected three regions for the study of institutional adaptation: (i) the state of Brandenburg in Germany, (ii) the state of California in the USA and (iii) the Ebro River Basin in Spain. A serious interest has been taken in the nature of change, its drivers and its agents. While it may be easier to trace the development of na-

1 A similar study, but one that does not focus on the agricultural water sector, has been conducted by IFOK GmbH. It assesses the strategies adopted by sixteen countries worldwide, including industrialised countries, to adapt to climate change (Meister et al. 2009).

tional adaptation strategies that are the likely outcome of recent high-level political attention and the various governments' commitments to combating and adapting to climate change, regional and local adaptation initiatives are triggered by a multitude of interrelated drivers, which will be identified in the following.

The study proceeds to clarify the role that climate change plays in agricultural water governance and, in Chapter 2, introduces potential drivers of change, while Chapter 3 presents the case studies selected, and Chapter 4 discusses the national adaptation strategies. The empirical Chapters 5, 6 and 7 describe the institutional initiatives revealed in the countries under investigation, and Chapter 8 summarises and discusses the drivers of these institutional initiatives and the relevance of vertical and horizontal collaboration and finally addresses the next research steps in a development context.

1 Climate change presupposes change in agricultural water governance

Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007). Climate change results in increased rainfall variability and global shifts in precipitation patterns, both of which severely affect the agricultural sector and its governing institutions. As droughts are a major concern for agriculture, they top the adaptation study agenda.

In water-scarce and drought-prone areas, water managers can often draw on in-depth knowledge accumulated over decades of drought management. In their projections, however, climatologists, ecologists and other members of the global scientific community argue that future events require additional, often modified initiatives to prevent the emerging aggravation of water shortages and its effects on the agricultural economy. Over a certain threshold of temperature increase, irreversible and possibly catastrophic changes become far more likely. Reactive approaches are therefore seen as inefficient and particularly unsuccessful in addressing damage, such as the extinction of species or irreparable damage to ecosystems due to climate change (Adger et al. 2007, 721).

Smith (1997) argued that adaptive measures should not be postponed and that adaptive policies should be pursued in anticipation of the impacts of climate change. Similarly, the *precautionary principle* calls for policies to cope with the emergence of increasingly unpredictable, uncertain and unquantifiable, but possibly catastrophic risks (UNESCO 2005). Adaptive and Integrated Water Management[2] and adaptive water governance are seen as concepts that address these problems (Huntjens et al. 2008; Herrfahrdt-Pähle submitted). Although both concepts seek to facilitate adaptation to climate change so that the related risks may be addressed, a distinction should be made between (adaptive) governance and (adaptive) management. Expressed simplistically, management is more about the operational aspects of water allocation, while governance generally refers to the making of rules (Folke et al. 2005, 444). In other words, who assigns water rights to whom? How are

2 Adaptive and Integrated Water Management has been defined as a structured process for improving management policies and practices through learning from previous management strategies (Huntjens et al. 2008).

trade-offs handled? Are externalities internalised? What are the management / operation modes, and should market-oriented approaches or state-administered, centralised or de-centralised approaches be invented?

The drivers and actors and the process of changing agricultural water governance are the particular focus of this study. According to Adger et al. (2007), natural events and climate projections are among the drivers. Global Water Partnership[3] (GWP) argues that strong organisations can cope with present climate variability and are in a better position to cope with future events (GWP 2009). In a recent GWP study Sadoff and Muller (2009, 5) argue that "finding the right mix of the three I's (information, institutions and infrastructure) to achieve the desired balance between the three E's (equity, environment and economics), will be the 'art of adaptation' in water management".

As institutions[4] are likely to be reconsidered and changed, this study examines institutional change and adaptation of agricultural water governance in three developed countries.

2 What drives institutional adaptation

Emphasising the need to reform water institutions is nothing new, and much has been written about the conditions that must prevail if domestic reforms in the (agricultural) water sector are to succeed (see, for example, Dinar 2001). This study describes institutional adaptation undertaken to cope with actual – and predicted – impacts of climate change on the agricultural sectors of three developed areas, namely Germany, Spain and the US State of California, and analyses why policy-makers and agricultural water administrations have initiated new approaches and concepts. We qualify all these initiatives as adaptation and 'institutional change', although they differ in degree and scale. Institutional change can be *intentional* and planned, as with the establishment of stakeholder forums, or *spontaneous* in response, for instance, to extreme natural or man-made events (Hayek 1964; Vatn 2005). Similarly, institutional change can be the result of *top-down processes* or *bottom-up initiatives*. While these characteristics can be understood as the two ends of a continuum, we assume that real cases commonly comprise attributes of both intentional and spontaneous processes and of both top-down and bottom-up initiatives at all levels (national, regional and local).

Processes of institutional change can be induced by a variety of drivers: by perceptions of predicted climate change impacts; by international obligations forcing politicians to take

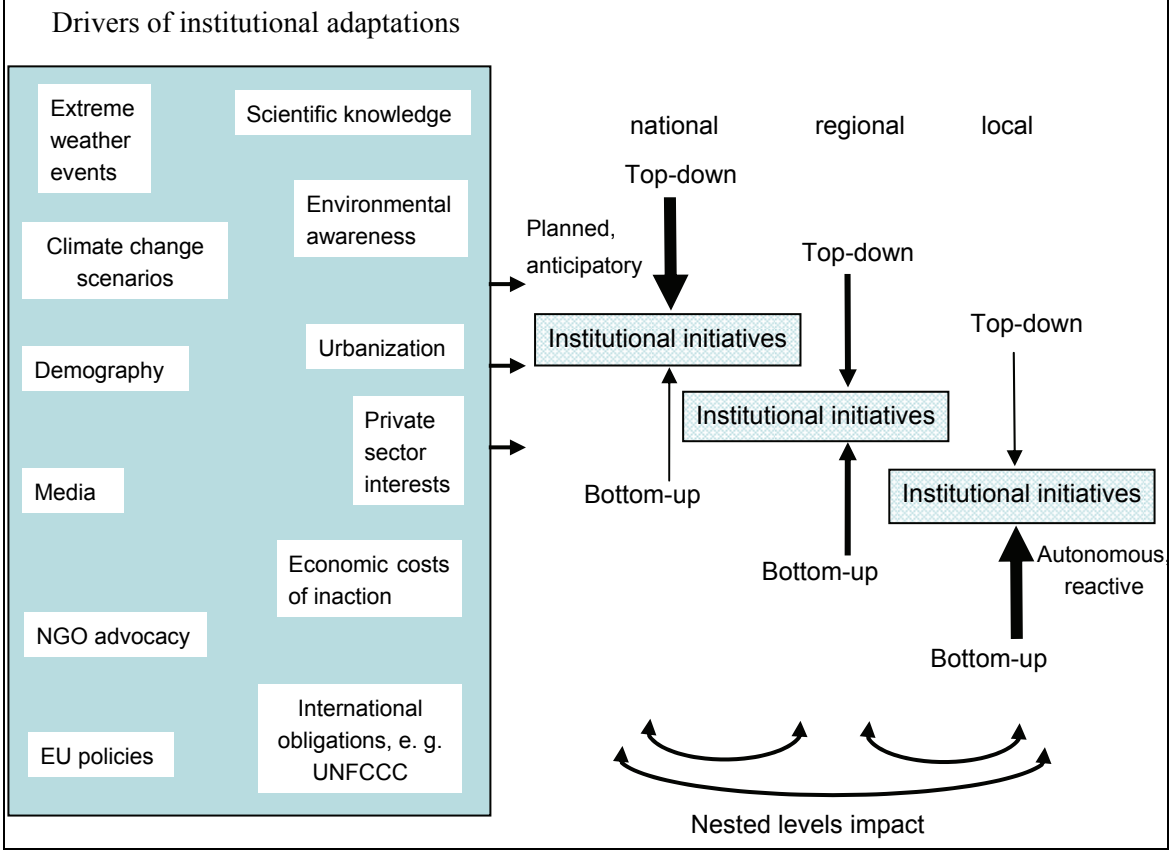
3 Global Water Partnership is an intergovernmental organisation of 13 regional water partnerships, 73 country water partnerships and more than 2,000 partner organisations in 150 countries.

4 Institutions can be understood as regulated relationships among people and among organisations, be they state agencies or other collective actors (Bromley 1989, 43), and define formal and informal bundles of rights and duties in relation to access to and use of water and land. As they provide incentives or disincentives for using and managing water (and related infrastructure), they govern relations among individuals and groups (whether voluntarily accepted through custom and tradition or enforced and policed by an external authority (i.e. external to the group of people using a resource). These *"rules are the means by which we intervene to change the structure of incentives (...). Rules are interesting variables precisely because they are potentially subject to change"* (Ostrom 1986).

action; by socio-economic concerns such as the cost of not taking action;[5] by the economic interests of the private sector. Drivers are manifold and often interact and, in many cases, reforms in the water sector may be driven by and associated with a larger reform agenda (Dinar 2001, 17).

Figure 1 shows the multitude of key drivers, the facilitating factors that induce the development of national adaptation strategies, and the institutional adaptations that have to be explored at different administrative levels. Following the classification of attributes

Figure 1: Multiple drivers of the adaptation of agricultural water governance to climate change



Source: Authors' own compilation

suggested by Horstmann (2008), we differentiate between autonomous and planned and between anticipatory and reactive adaptation.[6] The figure portrays our assumption that the

5 The Cost of Policy Inaction (COPI) method, for instance, is often used as an *ex-ante* evaluation tool to identify and roughly quantify the environmental damage that will occur if no new policy is designed to address the underlying (environmental) problem, or if the existing policies are not revised accordingly (Bakkes et al. 2006).

6 A similar classification is proposed by Swart et al. (2009, 27), who distinguish three types of adaptation: a) *anticipatory* adaptation, which takes place before impacts of climate change are observed, b) *autonomous* adaptation, which does not constitute a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems and by market or welfare changes in human systems, and c) *planned* adaptation, which is the result of deliberate policy decisions, based on an awareness that condi-

degree of planned and anticipatory top-down implementation decreases if actions are more decentralized and are introduced at the regional or local level. At the same time, we assume that the degree of autonomous and responsive adaptation approaches grows with actions at a lower administrative scale.

3 The countries selected

In line with Yin (1994), we will present three single (country) cases. The single-case design is a sensible approach whenever the topic of research provides for extreme or unique cases, such as a rare clinical syndrome in medicine or a revelatory case (Yin 1994, 38–40). However, it is not our aim to compare cases that were expected to produce divergent results on the basis of theoretical assumptions. Rather, we want to shed light on actual ongoing adaptation strategies, and particularly on institutional initiatives, and their drivers. To that end, we have selected the Land of Brandenburg in Germany, the State of California in the USA and the Ebro River Basin in Spain.

In each of the countries selected either a national or a state-level adaptation strategy has been introduced. Furthermore, each case has a hot spot of climate change, meaning a location where extreme weather-related events are experienced and where current forecasts predict a climate change-related trend towards a further aggravation of those events. For reasons of comparison, we focus on areas for which frequent local droughts are predicted.

In addition to these criteria, which are similar in all the cases selected, we adopted two contrasting criteria (Table 1 summarises the selection criteria):

— The political and governance context: We selected two member countries of the European Union and one case from the USA to contrast political decision-making driven by the EU legislative context with another political and regulatory regime. Both can be characterized as polycentric governance systems: California's irrigation sector has a high degree of polycentricism, with multiple governing authorities at different levels;[7] the EU's agricultural water sector is similarly polycentric, but less diversified.

— Relevance of climate change-induced impacts to agricultural production: In Brandenburg we find large areas of extensive agricultural production on marginal soil whereas intensive agricultural production in California is threatened by drought and salinisation. In the Spanish Ebro River Basin horticulture is exposed to a high risk of desertification.

The study is primarily based on an in-depth review of case-related documentary data, including the minutes of administrative meetings, project reports and press releases, as well as policy documents. All documentary data were obtained either directly from the respective authors and publishers or collected in a comprehensive internet survey. As a supplement to the analysis of the documentary data, a total of seven semi-structured interviews were conducted with experts from water administrations and research organisations in the

tions have changed or are about to change and that action is required to return to, maintain or achieve a desired state.

7 In a polycentric system, each unit enjoys considerable independence in laying down and enforcing rules within a defined domain of authority in a specified geographical area (Ostrom 2005; Ostrom et al. 1993, 179).

three countries observed. The interviews served to further confirm and, in some instances, redirect the analytical focus of the documentary review. The introductory chapters (1 and 2) and the concluding Chapter 8 are based on a review of academic publications related to our topic.

Table 1: Selection criteria for cases

Country / region	**Germany / Brandenburg**	**Spain / Ebro River Basin in the Catalonia region**	**USA / California, Upper Kings Basin**
Selection criteria	National strategy Hot spot Political and legislative context of the EU, polycentric governance system Extensive agricultural production Marginal soil conditions	National strategy Hot spot Political and legislative context of the EU, polycentric governance system Intensive horticulture Area at high risk of desertification	State-level strategy Hot spot Political and legislative context of the USA, higher degree of polycentricism Intensive agricultural production Area at risk of secondary soil salinisation and drought

Source: Authors' own compilation

4 National strategies of adaptation to climate change

National strategies of adaptation to climate change (NAS in the following) are currently being developed in many countries. Most NASs currently take the form of strategy papers or guidelines that set out mostly proposed, sometimes binding, frameworks for the measures to be taken. NASs address adaptation in a wide range of fields, including the agricultural water sector. They conform to the precautionary principle, as required by the UNFCCC (Horstmann 2008, 7), and so follow the underlying idea of integrating all sectors. Consequently, as the agricultural water sector is not always addressed separately, an NAS's implications for agricultural water governance are sometimes hardly recognisable.

The precautionary principle allows policy-makers to take discretionary decisions in situations where there is the possibility of harm resulting from a particular course of action or a certain decision where extensive scientific knowledge of the subject matter is lacking. The principle implies a social responsibility to protect the public from exposure to harm when scientific investigation has identified a plausible risk. Protection against risks may require coordination among administrations, a concern that is addressed by the NAS.

4.1 Drivers of the elaboration of national adaptation strategies

The national strategies described in the following are generally seen as a response to either direct ecological extremes or an increased awareness of climate change. It is, however, difficult to prove a direct causal link between certain events and the development of these strategies (Swart et al. 2009, 44).

At least one certain, major driver is of an international nature, primary examples being the United Nations Framework Convention on Climate Change (UNFCCC) of 1992 and recent policies adopted by the European Union. The UNFCCC obliges each party to the convention – including Germany, the United States and Spain – to establish a national policy to mitigate climate change. It further sets out the principle that each party must take precautionary measures to adapt to climatic impacts. The crucial role played by the UNFCCC in facilitating NASs is evident from the fact that the obligations it sets are commonly cited as a pivotal point of reference. The UNFCCC has urged the adoption of NASs even more directly under its Least Developed Countries (LDCs) work programme, which has led to the introduction of NASs in 43 developing countries by 2009.[8]

The European Union encourages the planning, conceptualisation and introduction of NASs, mainly because all actions proposed at EU level should be implemented in accordance with the principle of subsidiarity and complement actions at other levels (proportionality principle). The EU can also be regarded as a political arena in which countries balance and harmonise their actions (Swart et al. 2009). Innovative approaches adopted and experience gained by progressive member states are frequently seen as examples by those still in the process of planning or *ex-ante* assessment (ibid.)

The European Commission specifically addresses the need for NASs in its 2007 Green Paper "Adapting to climate change in Europe – options for EU action" and its 2009 White Paper "Adapting to climate change: towards a European framework for action." The White Paper calls for the implementation of an EU-wide adaptation framework to improve the member states' resilience in the face of climate change.[9] Agricultural water management and governance are considered in the accompanying sector papers on agriculture (EU 2009b) and water, coasts and marine issues (EU 2009c). The necessary funding will be forthcoming under the European Economic Recovery Plan and from the EU Emissions Trading System.

Adaptation, particularly in the area of agricultural water governance, is further influenced by the EU Water Framework Directive (WFD), the EU Water Scarcity and Drought Strategy and the EU Floods Directive. The WFD requires, for example, that natural water bodies be protected and restored and that their long-term sustainable use be ensured. This implies that adaptation to climatic impacts on water quantity and quality is a crucial task if the WFD's 2015 targets are to be achieved (EU 2009a).[10] In the same context, it is emphasised that the establishment of second-generation River Basin Management Plans by 2015 will make for "fully climate-proofed" adaptive water management (ibid). Agriculture will be at the centre of any such commitments, because it is by far the largest user and also a major polluter of water.

8 The LDC programme oversees various adaptation project initiatives in countries that have adopted an NAS. More than thirty agricultural water management and water governance projects are currently being implemented (UNFCCC 2009).

9 The EU-wide adaptation framework rests on four pillars of action: (1) building a solid knowledge base concerning the impact and consequences of climate change for the EU, (2) integrating adaptation into key areas of EU policy; (3) employing a combination of policy instruments (market-based instruments, guidelines, public-private partnerships) to ensure effective delivery of adaptation and (4) stepping up international cooperation on adaptation (EU 2009a, 7).

10 For a further in-depth discussion of EU water policies and their implications for national management standards see Aubin and Varone (2004).

4.2 Germany's National Adaptation Strategy

German policies on climate change mitigation date back to early 1990, when the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) was commissioned by the German Chancellery to set up and administer the Interdepartmental Working Group (IMA) on "CO_2 Reduction". While the IMA focused largely on the identification and communication of potential mitigation measures throughout the 1990s, it first raised the need for developing a German National Adaptation Strategy in 2005 (IMA "CO_2 Reduktion" 2005).[11] After two years of inaction the German government was eventually called on by the environmental ministers of the German federal states (*Länder*) to expedite the development of the national strategy for regional planning and action. The actual development process was launched in 2007 under the auspices of the BMU in cooperation with the Umweltbundesamt (UBA – Federal Environment Agency). The Ministries of the *Länder* were involved in the consultations. Various stakeholder groups were also included through public hearings and informal consultations (Swart et al. 2009). These consultations were organised by the Competence Centre on Climate Change Impacts and Adaptation, a special working group of the UBA mandated to enhance coordination and cooperation between science and policy-making (ibid.). It is reported that the participation of stakeholders has helped to integrate different perspectives into the NAS (Swart et al. 2009). The German NAS was ratified by the Federal Cabinet in December 2008.

The German NAS seeks to coordinate the work in progress in various ministries. The aim of the strategy is therefore to establish a transparent and structured medium-term process in which all the relevant actors are involved. It is also required progressively to ascertain the need for action, to define objectives, to identify and resolve conflicts and to develop and implement adaptation measures (Swart et al. 2009).

The document attached to the NAS includes a detailed analysis of regional vulnerabilities and possible adaptation measures drawn from a relatively broad scientific knowledge base. Among other topics, vulnerabilities and potential measures in the context of agricultural land and water management are discussed repeatedly, but in rather general terms. One of the major concerns raised is the regional effect of weather extremes, including droughts and heavy precipitation events. The NAS therefore proposes the improvement of water use efficiency in irrigation through water-saving technologies and waste-water recycling (German Government 2008, 22–23). It further emphasises that adaptive land and water management strategies, especially those which enhance water retention, will be needed in order to sustain wetlands, as will the continuous and balanced provision of water during droughts (ibid., 27). Adaptive land management, in particular those approaches that improve water infiltration, must also serve as a means of either preventing or mitigating floods (ibid., 43). To facilitate the implementation of these measures, the strategy proposes their integration into existing policies, such as the EU's WFD or Germany's agricultural structural policy (Gemeinschaftsaufgabe 'Verbesserung der Agrarstruktur und des Küstenschutzes'). Moreover, the development of vulnerability indicators and a national monitoring system is to provide the basis for a continuous review process.

11 In doing so, the IMA incorporated an earlier request which had been made in 2003 by the Sachverständigenkreis „Globale Umweltaspekte" (SV GUA), a thematic working group of the Federal Ministry of Education and Research (BMBF).

To facilitate the implementation of the NAS, the federal government will set up an inter-departmental working group on adaptation to climate change (adaptation strategy IMA). The working group, which will comprise representatives of all ministries, will be commissioned to connect the initiatives of government departments and to facilitate a dialogue and participation process. A concrete implementation programme for the German NAS is scheduled for April 2011. The working group is required to deliver regular reports concerning the progress made in implementing the NAS and its associated action plans. The first implementation report is scheduled for April 2013 (Swart et al. 2009). The responsibility for administering the working group rests with the BMU. The BMU is further required to chair a cross-level communication forum linking federal and *Land* agencies.

4.3 Spain's National Adaptation Strategy

The Spanish NAS dates back to a governmental decree of 2005, which was adopted as a law in 2006 (Swart et al. 2009). In the same year the Spanish Ministry of Environment, Rural and Marine Affairs (MARM) was instructed to draw up the *Plan Nacional de Adaptación al Cambio Climático* (PNACC) as a general framework instrument for mainstreaming adaptation into national policies. Like the German approach, the PNACC was drafted on the basis of consultations with various stakeholder groups. Additional input was provided by the Spanish Office for Climate Change (OECC) and its 2003/2004 project report on the "Effects of Climate Change in Spain". The OECC is responsible for distributing and administering the PNACC.

The PNACC identifies 15 key sectors for impact and vulnerability assessments and various adaptation options: biodiversity, water resources, forestry, agriculture, coastal zones, hunting and fishing, mountainous regions, soils, marine ecosystems and fisheries, transport, human health, industry and energy, tourism, construction and urbanisation, finance and insurance (Ministerio de Medio Ambiente 2006). Communication, public awareness, capacity-building and training within each sector are further key PNACC pillars.

Water resources are given a "priority for action" status, because their management is expected to become exceedingly important in the context of sustaining irrigated agriculture and other water-dependent economic activities. Alongside the PNACC, a nationwide "Study of Impacts on Water Resources and Bodies of Water" has been initiated. A general review of the progress made was carried out in late 2008; its findings could not, however, be assessed in this study.

In contrast to the German NAS, the PNACC contains no specific recommendations for agricultural water governance. The current version refers only to a general need for an integrated intersectoral assessment of the effects of climate change. This approach should enable sectoral interdependencies to be identified and, in the long run, also support the elaboration of integrative adaptation measures.

4.4 National Adaptation Strategy in the United States of America

The United States has not so far adopted a national adaptation strategy. An important reason for the USA's lagging behind Germany and Spain in this regard is that scepticism about climate change prognoses remains widespread and a matter of constant political controversy within American society. A number of individual states in which the political majority is concerned about the environment have reacted to the ongoing political stalemate at federal level by introducing their own state-wide adaptation strategies. California's Global Warming Solutions Act of 2006 and its Climate Adaptation Strategy of 2009 are probably the examples most often referred to.

At federal level efforts to arrive at a nationwide strategy currently consist of debates among the ruling political parties and interest groups. A number of adaptation policy drafts have entered the early stages of the legislative process. At least three of these drafts have the potential to develop into nationwide adaptation strategies which would have major implications for the future work of the country's agricultural water agencies.

The Water Efficiency, Conservation and Adaptation Act of 2009 (H.R.3747) acknowledges human-induced climate change and its effects on the water cycle, including expected shifts in precipitation patterns and increasing vulnerability to droughts in the country's south-western States.[12] The proposed measures include the establishment of a funding scheme by 2010 to provide financial resources for various adaptation activities, such as investment in existing irrigation infrastructure and the creation of groundwater storage and replenishment systems. The potential recipients of grants are private and public owners and water system operators at local, regional, state and federal level.

Similar action will be taken under the Water System Adaptation Partnerships Act (H.R.2969), the bill having been introduced by a group of California representatives in June 2009.[13] Grants will be made to water system operators to assist with the planning and implementation of adaptation measures and/or the further development of adaptive capacities. Water agencies applying for grants are required to demonstrate how their actions will improve the water system's resilience when affected by the climate by submitting specific adaptation implementation plans. Funds are allocated in accordance with an agreement under which costs are shared between federal and non-federal sources. The non-federal share will be borne by the owners and operators of the water system. The Environmental Protection Agency (EPA) will function as the lead agency for the implementation of H.R.2969.

A third notable policy effort, the Natural Resources Climate Adaptation Act (S.1933), will require federal agencies, including those responsible for water management, to prepare an NAS and intra-agency working plans. It also requires the establishment of a federal Natural Resources Climate Change Adaptation Fund, which will be used to finance state-level

12 H.R.3747 has been referred to in a number of congressional–committees, including the House Transportation and Infrastructure Committee, the House Natural Resources Committee, and the Subcommittee on Water and Power (GovTrack.us 2009).

13 At the time of writing H.R.2969 has been referred to the following congressional committees: the House Committee on Transportation and Infrastructure; the Subcommittee on Water Resources and Environment; the House Committee on Energy and Commerce.

adaptation measures.[14] Grants will be allocated on the basis of specific natural resource adaptation plans. According to the current wording of S.1933, a considerable proportion of the funds will be distributed to federal and state agencies heavily involved in agricultural water management and the construction and maintenance of irrigation infrastructure.[15]

In sum, it is striking that all three US initiatives were introduced by political representatives of states and regions which are both highly vulnerable to climate change and economically dependent on irrigated agriculture: the Water Efficiency, Conservation and Adaptation Act was sponsored by politicians from the State of Nevada; the Water System Adaptation Partnerships Act was introduced by a representative of the State of California and co-sponsored by politicians from other drought-prone states, such as Arizona, Oregon and Missouri; the Natural Resources Climate Adaptation Act dates back to an initiative of representatives of the States of New Mexico, Missouri and Montana.

5 Brandenburg, Germany

5.1 Hydrological trends and agricultural production in Brandenburg

The *Land* of Brandenburg is characterised by a negative water balance and – because of climate change – increasingly frequent and severe droughts (Gerstengarbe et al. 2003). Wechsung et al. (2008) estimate that the future reduction of water availability in Brandenburg will lead to a ~15 per cent decrease in crop yields by 2046. Agriculture is a major economic sector in Brandenburg. Around half of Brandenburg is used for agricultural purposes, large areas being devoted to extensive forms of production. In those areas, sandy soils of marginal quality and low water availability permit only low-input rye production and a small number of dairy farms of low stocking density. The low retention capacity of these sandy soils is the main reason for the extreme yield losses in dry periods (Projektgruppe Landschaftswasserhaushalt 2003).

At least since the late 1990s, the consequences of water shortages for water-dependent sectors, such as agriculture, horticulture and forestry, have attracted increasing attention from policy-makers, bureaucrats and the public. The extremely dry summers in 1992, 1997 and 1998 and a particularly low precipitation rate in the spring of 2000 resulted in yield losses and drought damage, estimated to be as high as EUR 153 million in 2000 alone (Schleyer forthcoming 2011; Projektgruppe Landschaftswasserhaushalt 2003).

14 At the time of writing the draft is being revised by the Senate's Environment and Public Works Committee, which will decide whether the Bill is to be transferred for further review in Congress, this being the final step before the Bill can be signed into law by the President (Climate Science Watch 2009).

15 Among the proposed recipients are the Federal Bureau of Reclamation; the United States Secretary of Agriculture, the United States Geological Survey; and the United States Army Corps of Engineers.

5.2 Organisational structure of Brandenburg's agricultural water administration

As a federal state, Germany consists of 16 federal states (*Länder*), each endowed with legislative and administrative powers to manage the use of water resources, among other things, in agricultural areas and for agriculture-related purposes. As a result, different structures governing water and land resources have been established in the various *Länder*.

In Brandenburg, the administration of the public water sector consists of three layers: first, the Brandenburg Ministry of Environment, Health and Consumer Protection (MUGV) is the "highest water authority" (until November 2009 this responsibility rested with the Ministry of Agriculture, Environment and Regional Planning). Second, the Environmental Agency of Brandenburg (LUA) serves as the "higher water authority" and is supervised by the MUGV. It advises the Ministry on all scientific and technical issues relating to water management. The LUA further oversees the activities of the third administrative layer, the "lower water authorities," which form part of the local government at district level (*Landkreis*, or county) and also provides the lower water authorities with scientific and technical support (see Figure 2).

The LUA is responsible for operating the barrages (*Stauwehre*) on first-order watercourses, but the lower water authorities must approve the water retention targets (Monsees / Grossmann 2004). Regulating the water level of second-order watercourses is the responsibility of the owners of the barrages, but here again, the water retention targets must be approved by the lower water authority.

Water and soil associations (WSAs), which date back to dike cooperatives that emerged in the 11th century, are a particular feature of German agricultural water management (Monsees 2004). Today's water and soil associations are autonomous and membership-based public-law institutions, their areas of jurisdiction usually being defined by the boundaries of hydrological units, rather than those of administrative districts. Among other things, they organise collective action at local level for the management of water and land resources for agricultural purposes, including drainage and irrigation. This includes, in particular, activities that are beyond the financial and technical capabilities of individual landowners or land and water users and tasks for which coordinated actions are crucial, such as the maintenance of reclamation infrastructure[16] and the operation of barrages.

In 1991, unlike most federal states in West Germany, the government of Brandenburg established a *Land*-wide network of 26 WSAs, each covering a distinct watershed area. The associations are primarily responsible for maintaining second-order watercourses[17] (Monsees 2004; 2008). Membership of the associations is compulsory for all municipalities representing landowners required to pay land rates. However, it is the tenants who

16 Reclamation infrastructures are the technical devices needed to fulfill the interlinked functions of irrigation and drainage.

17 In the federal state of Brandenburg, second-order watercourses (with a total length of about 30,700 km) are all open watercourses which are not of primary importance for overall landscape water management, for nature and water protection or for water use. They are usually smaller than first-order watercourses (over 2,000 km), but not necessarily so.

effectively pay the membership fee as an implicit part of their rent. Landowners who are not subject to land rates, such as railway companies and state agencies, are direct, i.e. non-represented, members. Other interested stakeholders, such as agricultural and environmental associations, can be voluntary members. Within the area of their legally defined functions, the WSAs can exercise mandatory authority over their members. The territorial jurisdiction of WSA management varies according to the length of open first- and second-order waters and the density of water courses in their area. All WSAs operate under the supervision of the higher water authority, i.e. the LUA (Schleyer forthcoming 2011).

In the former German Democratic Republic local drainage advisory boards (*Staubeiräte*) were established in 1966 (Monsees / Grossmann 2004). As advisory bodies, their members included representatives of the WSAs in their area, regional agricultural and environmental administrations (including the lower water authority), agricultural firms and other land users and local stakeholders. Interestingly, although formally dissolved during the reunification process, some of these drainage boards continued their work to some extent either informally or under another name (Monsees / Grossmann 2004). In 1997 an amendment to Brandenburg's water law led to their official approval as drainage advisory boards, and they were empowered to decide on water management issues, particularly in complex agricultural drainage areas (Schleyer forthcoming 2011).

5.3 Initiatives in Brandenburg

The following three examples illustrate both higher-level innovations, such as the Working Group on the "Landscape Water Regime," and lower-level innovations, such as the setting up of local drainage advisory boards.

5.3.1 Local drainage advisory boards

In agricultural drainage areas, the functions of irrigation and drainage are always closely interlinked and determined by complex and interdependent systems of technical infrastructure. This infrastructure usually consists of canals, ditches, barrages, weirs and pumping stations. Such reclamation systems have substantial impacts on water and land resources in the drainage area and even beyond. Thus, in addition to the climatic trends outlined above, they also contribute to declining water availability in Brandenburg by lowering water tables, further reducing water retention capacities of agricultural and other soils and degrading wetlands (Schleyer forthcoming 2011; Landgraf 2001; MLUR 2001). Here, the numerous barrages and weirs – up to 14,000 in Brandenburg – play a crucial role, since they allow the drainage effects of reclamation systems to be controlled and water to be retained in the region. Their operation is therefore a key to the stabilisation of a landscape's water regime.

In this respect the local drainage advisory boards are important institutions. In some areas of Brandenburg, such as the Schraden, they were relaunched as a bottom-up initiative because of growing water retention problems in the area and long-term climate change scenarios forecasting an increase in summer droughts accompanied by low water tables. The rebirth of a local drainage advisory board is considered here as a new institutional initiative since it now performs the functions of negotiating agreements and coordinating bar-

rage and weir operations. This complements measures taken by WSAs, which seek more technical solutions (see below).

In the past, however, the coordinated operation of the infrastructure (i.e. the barrages and weirs) proved difficult because of conflicting interests of (regional and other) stakeholders with regard to appropriate water table levels (Schleyer forthcoming 2011), not least because of unclear property rights to relevant elements of the reclamation infrastructure and, in some cases, still unclear land property rights.

5.3.2 Working Group on the "Landscape Water Regime"

The severe spring drought in 2000, which resulted in a loss of EUR 150 million in the agricultural sector (Projektgruppe Landschaftswasserhaushalt 2003), was one of the main factors that eventually drove the Federal Ministry of Agriculture, Environment and Regional Planning (MLUR) to establish an interdisciplinary Working Group on the "Landscape Water Regime" (Schleyer forthcoming 2011; Landgraf 2001), this being the second climate change-related institutional initiative. The working group was chaired by the president of the LUA, its members being representatives of the LUA and the MLUR and many experts (in the fields of water management, agriculture, regional planning, biology, wetland renaturation, forestry, etc.), non-political stakeholders and experts being invited as appropriate. It represented an innovative form of horizontal cross-agency collaboration among agencies and stakeholders at the same administrative level. The group's activities were aimed at:

(1) clarifying the impact of climate change on the landscape water regime in Brandenburg by assessing the effects of diminishing summer precipitation and rising mean temperatures and

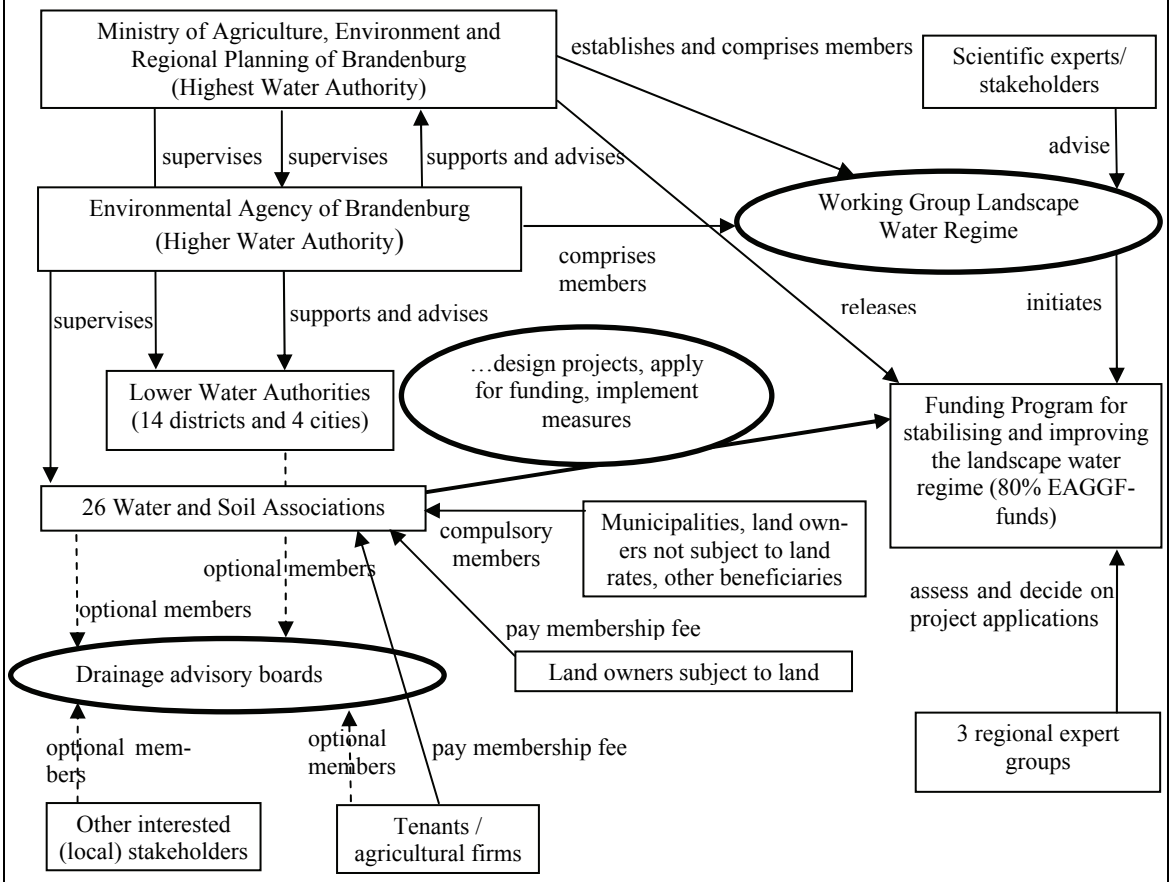
(2) developing, testing and assessing options for adaptive measures taken to ensure the sustainable use of water, with climate change-induced changes taken into account (Schleyer forthcoming 2011; Landgraf 2001).

5.3.3 Empowerment of the water and soil associations

Based on the Working Group's assessment of the current state of the landscape water regime in Brandenburg and its recommendations for measures to be taken, a Brandenburg-wide Funding Programme ("*Land*-wide programme for stabilising and improving the landscape water regime") was launched by the MLUR at the end of 2001 and extended in 2004 and 2009. Above all, by promoting habitat and forest restoration measures, land use change and the modernisation of existing reclamation infrastructure, the programme sought to improve the water retention capacity of watersheds. The tasks of designing practical measures, applying for funds and implementing the various measures of the programme, however, were/have been delegated to local water and soil associations, thus creating a range of new adaptation-oriented tasks for them to perform.

Thus, directly linked to the establishment of the Working Group and its activities is the third institutional initiative described here, namely the empowerment of the WSAs. Im

Figure 2: Agriculture-related adaptation initiatives in Brandenburg's water administration



Source: Author's own compilation

plementing measures in collaboration with the respective local WSA represents a form of vertical collaboration, i.e. cooperative efforts among macro-level and local-level agencies and various stakeholders and social groups.

To implement the Funding Programme, three regional groups of experts were formed to assess the project proposals submitted. Although the Working Group on the "Landscape Water Regime" was finally disbanded in spring 2003, these three regional working groups have continued their work, thus demonstrating the long-lasting effect of this regional institutional initiative.

Funding for the aforementioned measures is largely obtained from public sources, particularly the EU's European Agricultural Guidance and Guarantee Fund (EAGGF) budget.[18] By the end of 2007, 400 local projects totalling EUR 70 million had been implemented, EUR 54 million being contributed by the EAGGF (Schleyer forthcoming 2011). The conditions attached to this line of funding mean that 20 per cent of the project costs

18 The EAGGF is composed of two sections, the Guidance section and the Guarantee section. Under the European economic and social cohesion policy, the EAGGF supports rural development and the improvement of agricultural structures.

have to be covered by the applicants, i.e. the water and soil associations. The WSAs pass these costs on to the beneficiaries of the projected measures.

The programme's success is evident from the high number of concrete technical measures implemented by 2007, such as the construction or reconstruction of about 1,600 barrages and weirs, the dismantling of 170 weirs and the construction of 1,000 low weirs (Schöfer 2008). Yet, if the water and soil associations had not been authorised to design such technical projects and if the financial resources had not been provided, the implementation of this programme would not have been possible. The Working Group's coordinator stated that the raising of public awareness of water balance issues was an additional benefit of the programme. Figure 2 shows the organisational structure of Brandenburg's agricultural water administration, including the institutional initiatives described above.

6 The Ebro River Basin, Spain

6.1 Hydrological trends and agricultural production in the Ebro River Basin

Climate change in Spain is reflected in a general trend towards higher mean temperatures accompanied by a decline in annual precipitation. It is predicted that most of the country's semi-arid regions in the south and centre of the Iberian Peninsula will suffer from a dramatic 50 per cent loss of water yields by 2050 (IPCC 2007). Almost as dramatic are the predicted impacts on regions which, until recently, had enough water to sustain both intensive agriculture and a dense urban population. The Ebro River Basin, which currently supplies water to more than 784,000 hectares of agricultural land and over 3 million urban users, is, for instance, forecast to receive 5 to 15 per cent less precipitation by 2050 (ibid.). The consequences will be decreasing replenishment of groundwater and also decreasing river runoff, both of which are important sources for irrigated agriculture in the area.

6.2 Organisational structure of the Spanish agricultural water administration

The Spanish Water Law of 1985 and the Spanish Constitution call for a division of administrative tasks between macro-level state water agencies, such as the National Ministry of Environment, and the administrative organs of the Autonomous Communities. The division of responsibilities among the agencies is based on the location and territorial size of the country's river basins (Dähne 2000). A river whose course is confined to a single Autonomous Community's territory is governed solely by that community's competent bodies. Each river basin is thus treated as a physically and politically indivisible body (Dähne 2000). River basins that extend beyond a single community's boundaries are, on the other hand, the responsibility of the central government and assigned to River Basin Organisations (Confederaciones Hidrográficas, RBOs) (Saleth / Dinar 2004). Similarly, the territorial jurisdiction of a River Basin Organisation may extend to one or more rivers.

Today, the organisation of large parts of the country's water sector is shared by 14 major RBOs. These RBOs, though formally operating under the Ministry of Environment, Rural and Marine Affairs (MARM), are the executive arm of the water administration responsi-

ble for water development, resource allocation, pricing, etc. (Saleth / Dinar 2004). The Ebro River Basin Organisation, for instance, oversees the Ebro and also parts of the Garonne and the watershed area that drains into the Gallocanta lagoon.

The RBOs are assigned to perform several administrative functions, including:

— The development, monitoring and review of River Basin Management Plans (including those which are to be developed under the EU's WFD)

— Administration and control of public waters

— Design, construction and operation of works carried out with the agency's own funds and those assigned to it by the Spanish government

— Administration and control of water uses that affect more than one Autonomous Community

— Fulfilment of obligations arising from agreements with Autonomous Communities, local authorities and other public or private entities

To perform these tasks, RBOs are entitled *inter alia* to:

— Grant approvals, concessions and use rights to private water users

— Monitor and sanction all activities taken within the scope of those approvals, concessions and use rights

— Set binding thresholds and targets for water quality and quantity

All RBOs act through their governmental, administrative and advisory organs, which are again composed of representatives of the national administration, the riparian Autonomous Communities and the private water sector, including urban water suppliers, energy producers and, what is exceedingly important, local Irrigation Communities in their role as representatives of the farmers.[19] The water law allows users to obtain use- and source-specific water and discharge permits from RBOs (Saleth / Dinar 2004). The Irrigation Communities, the lowest level in agricultural water administration, thus play an active part in river basin management.

Local Irrigation Communities are under an obligation collectively to administer the public surface and groundwater resources they share (FENACORE 2010). Their foremost task is the distribution of water and assigned water use-rights and to enforce associated regulations (ibid.). The Irrigation Communities are entitled to collect contributions to cover the shared expense of exploitation, maintenance and technical improvement and of the administration of water distribution (ibid.). Another important task performed by these Communities is the settlement of conflicts between agricultural water users.

In legal terms, Irrigation Communities are public-law corporations and enjoy managerial autonomy within the statutory limits imposed by individualised ordinances and regulations

19 The RBOs are headed by the RBO's president and it's Governing Board. Their administrative and advisory organs are the Assembly of Water Users, the Commission on Dams and Reservoirs and the Water Council. For an in-depth discussion of the RBOs' organisational set-up see Dähne (2000) and Costeja et al. (2004).

drafted by the irrigators themselves and then submitted for final approval to their respective Basin Agency (ibid.).[20]

Today there are around 6,200 local Irrigation Communities country-wide (FENACORE 2010) in 313 General Irrigation Communities, each serving as a regional umbrella organisation and all members of the National Federation of Irrigation Communities (FENACORE – Federación Nacional de Comunidades de Regantes de España). In the Ebro River Basin there are currently 53 General Irrigation Communities concerned with agricultural water management.

6.3 Institutional initiatives in Spanish water governance (Ebro River Basin)

While we are considering the central role played by the RBOs in water administration in Spain today, reference should also be made to this spatial and organisational level in the discussion of potential innovations for adapting water governance. The three examples presented in the following are initiatives whose scope extends beyond the agricultural sector and so reflects the general search for holistic, integrative solutions for climate change-induced impacts (see the earlier discussion on NASs). Nevertheless, all three examples demonstrate how significant the agricultural water sector is both in economic terms and as the largest user of water resources.[21]

The first example, the ALBERCA programme, is a recent macro-level policy initiative aimed at improving the Spanish register of groundwater rights. The RBOs, which have been assigned to implement ALBERCA, hoped to benefit from the improved register, especially in their efforts to fulfil future EU WFD obligations to ensure ecologically sound and adaptive irrigation management. The second example comprises initiatives which evolved as a direct consequence of collaborative efforts within one RBO. In this context, we refer to the RBO "Ebro Hydrographic Confederation" (EHC) and its 2007 basin-wide Special Plan of Action in Cases of Possible Drought Alert. The last example is the Catalonian climate change strategy, which is noteworthy because its creation stemmed from a unique cross-level / cross-sectoral participatory process that led to the Catalonian Convention on Climate Change.

6.3.1 The national ALBERCA Programme for registering water rights

Although the 1985 Spanish Water Law declares groundwater to be public property, only wells whose drilling was authorised after 1986 in fact yield public water (Llamas et al.

20 Water users and users for any other public purpose who share the same outlet or concession are legally required to organise themselves into "Users' Communities". Where water is used only for irrigation, these communities are known as "Irrigation Communities" (FENACORE 2010).

21 In the Ebro River Basin, for example, irrigated agriculture accounts for 51 per cent of the total area of the basin and uses 89 per cent, or 6,130 hm^3/year, of the water. Urban areas, on the other hand, account for only ~1 per cent of the land and 7 per cent, or 506 hm^3/year, of the water, the industrial sector for less than 1 per cent of the land and only 4 per cent, or 250 hm^3/year, of the water (Ministerio de Medio Ambiente 2007).

2007). The total number of wells and the actual amount of water uptake is not formally known even today.

The country's water agencies, including the River Basin Organisations and their members, encounter major problems in the management of groundwater owing to the high degree of uncertainty about actual usage (ibid.). Furthermore, distributional conflicts cannot be adequately resolved unless accurate assessments of storage and exploitation rates are available. Illegal groundwater exploitation is a growing problem for agencies involved in the management of the water systems of such coastal cities as Valencia. However, it is of possibly even greater significance in irrigated agriculture, which is about 62 per cent dependent on groundwater (Lopez-Geta et al. 2008). Many local Irrigation Communities are overburdened by their task of calculating individual water uptake rates and members' contributions. A further challenge lies in the precise assessment of the state and quality of available groundwater; this is a serious obstacle to any monitoring, planning and maintenance and also to conflict resolution.

The Spanish Water Plan of 2001 sees a functional registry of water rights as a fundamental prerequisite for the sustainable management of water within the RBO framework. The plan also stresses that a registry is an essential tool for meeting the environmental requirements laid down in the European Water Framework Directive – including those addressing climate change adaptation in the future. In 2002, the Ministry of Environment acted on these statements by initiating the ALBERCA programme (2002–2008). The acronym ALBERCA stands for Actualización de Libros de Registro y Catálogo (Updating of Registry and Catalogue Books).

The aim of the ALBERCA programme was to update and enhance the existing groundwater register by establishing a set of homogeneous basin-wide administrative procedures. Its implementation was delegated to the country's 14 River Basin Organisations. To enable the register to be compiled, the local Irrigation Communities were required to provide data on their members. This necessitated a considerable input of time and human capital by local agencies and collaboration with RBO bodies at a higher level.

The supervision of ALBERCA was assigned to the General Office for Management of the Public Hydrographic Domain and the General Office of Information Systems and Services. A public company was contracted to provide technical support.

A software package was created to help the RBOs with the processing of the vast amount of registration confronting them, a task that had frequently overburdened them in the past. Furthermore, many of the local Irrigation Communities had used different and often incompatible data management procedures. The ALBERCA registration software was accordingly developed to homogenise and modify previous administrative methods and to accelerate the processing of information. One of the strengths of the ALBERCA software is its digital mapping capacity, which permits the detection of inconsistencies and duplications.

The River Basin Organisations were given technical support, training and total funding of EUR 155 million. By September 2004, the programme had been implemented in seven administrative basins (Llamas et al. 2007). Ferrer et al. (2004) estimate that by that time about 300,000 applications had already been recorded on the ALBERCA database.

The introduction of ALBERCA was based on the understanding that clearly defined and transparent water rights and a continuously updated registry are essential both for citizens and for the civil service, given its legal obligation to manage public waters sustainably. The initiators expect the revision of the water rights system to improve the functioning of RBOs substantially and especially, within this framework, the performance of local Irrigation Communities, which represent by far the largest number of groundwater users in the country. This is expected to have positive effects for the process of granting concessions, the establishment of plans, the optimisation of resource exploitation, the control and sanctioning of uses, the provision of citizens' advice, and the collection and billing of fees.

There is a worldwide trend by governments to control groundwater resources by declaring that they are a public domain. Yet, even when the state claims ownership rights to a body of groundwater, individual or collective users may nevertheless hold abstraction and use rights (Theesfeld 2010). Thus with the installation of a water register the former water owner can easily be turned into a user who must apply to the state for rights of water abstraction and use. In that sense, the Spanish register may become a mechanism for adaptive irrigation management by facilitating the reallocation of formal water rights and the setting of maximum water withdrawal quotas. This is seen as one of the prerequisites for coping with climate change and controlling water usage. Finally, the outcome of ALBERCA, i.e. a functioning register of groundwater rights and use, is meant to allow better coordination among water agencies at all levels.

6.3.2 The Drought Plan of the Ebro River Basin Organisation

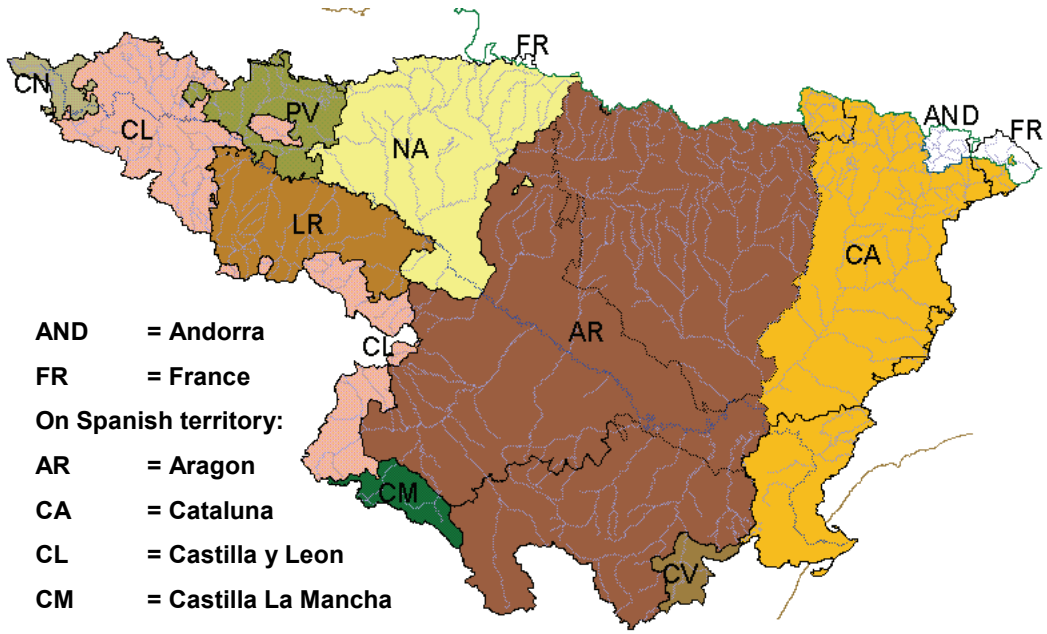
The Ebro River Basin stretches over Spanish, Andorran and French territory. The Spanish part of the Ebro River Basin is administered and managed by the River Basin Organisation "Ebro Hydrographic Confederation" (Confederación Hidrográfica del Ebro; EHC).[22] The EHC, which was founded in 1926, has undergone several phases of organisational change. Today, it oversees 85,534 km^2 of territory extending into nine Autonomous Communities and including 18 provinces and 1,717 municipalities (see Figure 3).

Irrigated agriculture is a major industry in many parts of the Ebro Basin. The Autonomous Communities of Navarra, Castilla y León and La Rioja are, for instance, important areas of horticultural and vinicultural production. Currently, some 800,000 hectares of land are under irrigation.[23] The 100,000 people working in agriculture generate EUR 2.6 billion of produce each year.

22 The Ebro riparian states have also established three international commissions to deal with transboundary water management issues: the Joint Committee for Lake Lanoux; the Hispano-French Joint Committee of the High Garonne; and the Hispano-French Joint Commission on Boundary Waters (Ebro Hydrographic Confederation 2009).

23 The EHC has calculated that 91 per cent of the water used for irrigation stems from surface sources, mainly the Ebro and its tributaries. Common methods of irrigation in the watershed area are gravity irrigation (69 per cent); spray irrigation (19 per cent) and only a comparatively small proportion of resource-conserving drip irrigation (11 per cent) (Ebro Hydrographic Confederation 2009).

Figure 3: National and international administrative divisions in the Ebro River Basin



AND = Andorra
FR = France
On Spanish territory:
AR = Aragon
CA = Cataluna
CL = Castilla y Leon
CM = Castilla La Mancha
CV = Castilla Valencia
LR = La Rioja
NA = Navarra
PV = Pais Vasco

Source: Ebro Hydrographic Confederation (2009)

The EHC has recently introduced a number of innovative measures to combat the growing threat of drought within its jurisdiction. A Special Plan of Action in Cases of Possible Drought Alert (Ebro Drought Plan – Plan Especial de Actuación en Situaciones de Alerta y Eventual Sequía) has been issued as a supplement to the general Ebro River Basin Management Plan. The Ebro Drought Plan drafted by the EHC in 2006 was criticised by the EHC's members and external interest groups, such as the OECC (Oficina Española de Cambio Climático), the World Wide Fund for Nature and the National Ministry of Environment (Ministerio de Medio Ambiente 2007) and has been repeatedly revised. The agricultural sector has participated in drafting the plan with the largest group of representatives, including FENACORE and five General Irrigation Communities, which are members of the EHC.[24] The final version of the plan was submitted to the EHC's Water Council in 2007.

The Ebro Drought Plan, which was drawn up as a consequence of the pledge set out in the National Water Plan to find regional solutions to the ubiquitous drought problem, includes a comprehensive analysis of the causes and effects of past and present droughts and addresses climate change as one potential cause (Ministerio de Medio Ambiente 2007). The

24 Federación de Comunidades de Regantes de la Cuenca del Ebro; Comunidad General de Riegos del Alto Aragón; Canal de Aragón y Cataluña; Comunitat General de Regantes del Canal de la Dreta de L'Ebre; Communidad General de Regantes del Canal de Bardenas.

dresses climate change as one potential cause (Ministerio de Medio Ambiente 2007). The irrigation sector is repeatedly referred to as being disproportionately vulnerable and, consequently, deserving of special attention with regard to emergency assistance (ibid., 79).

The plan further proposes a catalogue of drastic alert measures to which the EHC's members may refer in times of acute water crisis. These alert measures include a temporary change of the conditions attached to water concessions regarding discharge authorisations, assignments and reservations (Ministerio de Medio Ambiente 2007). Water may accordingly be redirected from one use to another, and considerable amounts may, for example, be diverted from hydroelectric power stations to irrigation (ibid.). In addition, local Irrigation Communities may require the immediate installation of devices for the modulation, control and measurement of pipelines (ibid.). Farmers who remain undersupplied will be offered compensation. Furthermore, in an acute drought, the regional governments are called upon to make it easier for irrigators to gain rapid access to money by easing credit requirements (ibid.).

In sum, the plan offers a variety of concrete regulatory measures, many of which have a direct impact on irrigators' access to water. This striking level of support for the Irrigation Communities can be ascribed to their economic importance and their status as the largest water users in the basin. Another reason is that the formally assigned mode of representation within the RBOs' governance structure gives disproportionate weight to the Irrigation Communities (Kemper et al. 2005).

The Irrigation Communities are in turn asked to take strong adaptive measures themselves. The plan accordingly lists a number of actions to be taken in "pre-alert", "alert" and "emergency" situations. For pre-alert management the communities are, for example, required to establish, standardise and communicate internal norms for the apportionment of water flows among their members. During alert and emergency situations, they must increase the monitoring and control of local water use and make eventual cuts in water allocation (Ministerio de Ambiente 2007).

The implementation and administration of the plan have been assigned to a Permanent Commission on Droughts (Comisión Permanente de la Sequía), which was set up in 2008. The commission is an example of horizontal and vertical collaboration, in that it is chaired by the EHC's president and otherwise consists of a number of high-ranking EHC staff members, officials from the National Ministry of Agriculture, Fisheries and Food and the National Ministry of Industry, Tourism and Commerce and representatives of environmental interest groups and water users, where the Irrigation Communities again play a leading role.

6.3.3 The Catalonian Convention on Climate Change

The Autonomous Community of Catalonia is a regional leader involved in activities to combat climate change. In late 2006, its government established (i) the Catalonian Office on Climate Change and (ii) the Interdepartmental Commission on Climate Change to define future action to integrate sustainability criteria into its economic policies, including those related to the work of Catalonia's Irrigation Communities.

Catalonia is one of seven Autonomous Communities adjoining the Ebro Basin to have adopted their own regional climate change strategies.[25] In Spain as a whole, 18 similar regional strategies have so far been introduced (Ribeiro et al. 2009); all were created under the umbrella of the Spanish PNACC (see the section on Spain's NAS), and all place considerable emphasis on agricultural water management as a key priority for action. The Catalonian Climate Change Mitigation Strategy (Plan Marco de Mitigación del Cambio Climático en Catalunya) was introduced in 2008. Its main goal is to serve as an early framework for the Community's contribution to Spain's commitment to the Kyoto Protocol. Despite this primary focus on mitigation, the strategy also addresses adaptation.

The introduction of the Catalonian strategy was led by two macro-level administrative bodies, namely the government of Catalonia and the Catalonian Department of the Environment. Catalonia's government also provided funding throughout the drafting process, which took from mid-2007 until early 2008. Its creation was instead based on innumerable public meetings and hearings attended by a vast number of stakeholders, including representatives of the agricultural sector. To this end, the public were invited to attend the Catalan Convention on Climate Change, a process analogous to the government's internal planning efforts. The aim of the convention was to gather opinions / ideas from all the stakeholders in civil society.[26] At the time, this was a novel process in terms of both the scope of the subject being addressed and the participatory methodology used (Generalitat de Catalunya 2009).

In total, over 800 participants from 500 public and private organisations attended the convention (Ribeiro et al. 2009). The stakeholder groups comprised private companies, associations, universities, trade unions, local water agencies and local and regional administrative boards (ibid.). During the workshops the stakeholders were divided into seven thematic working groups (i.e. transport, information and public awareness, agriculture, forestry, urban planning, energy, industry and waste management). Each is reported to have undertaken sectoral situation analyses and to have developed associated action plans (ibid.). Proposals were gathered from the various working groups. In the end, more than 1,000 proposals were submitted (Generalitat de Catalunya 2009).

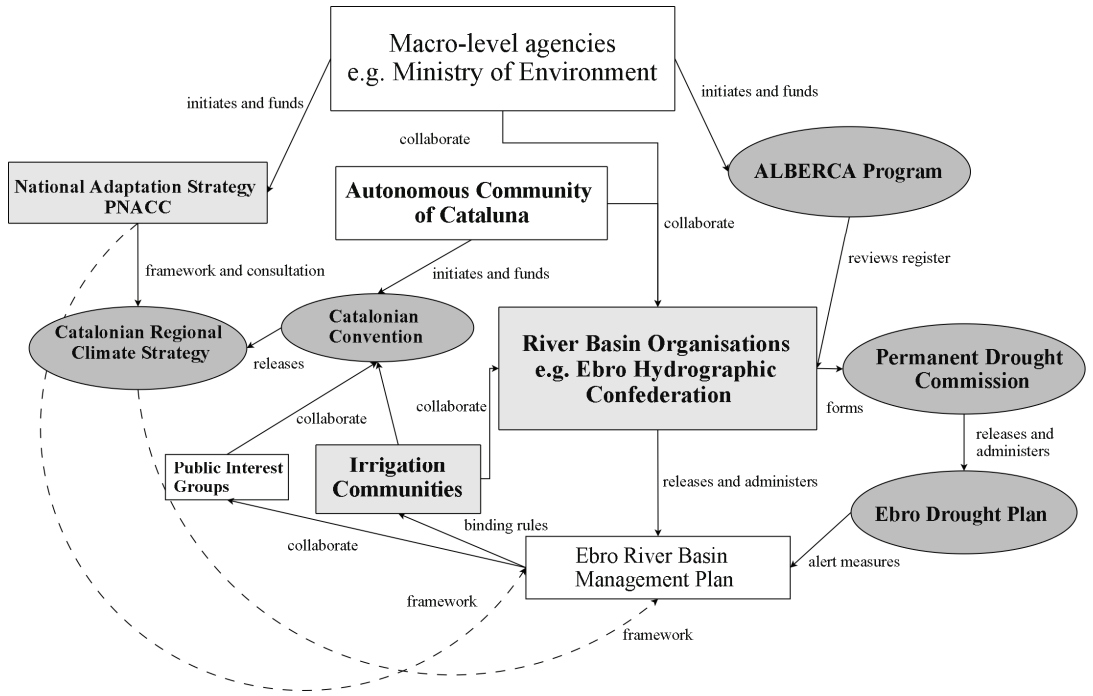
The final document sets 2012 as the deadline for action. The total annual cost of implementing the strategy is calculated at EUR 195 million (Ribeiro et al. 2009). It emphasises *inter alia* the need to foster ecologically sound management of water resources. The strategy therefore calls for the introduction of water-saving technologies in agriculture. The use of water in rural and peri-urban areas should be optimised; and current patterns of land use should be revised with a view to improving irrigation. The proposals for measures affecting agricultural water use call on local Irrigation Communities to play a leading role in implementation. A local environmental audit network should also be established (Generalitat de Catalunya 2009).

25 Regional climate change strategies have been introduced by the following Ebro riparians: Castilla La Mancha, Aragón, La Rioja, País Vasco, Cantabria, Valencia and the City of Zaragoza (Ribeiro et al. 2009). Navarra and Castilla y León are therefore the only riparian communities that have yet to adopt a regional strategy.

26 The convention was organised by the Catalonian Office on Climate Change in cooperation with the General Sub-Directorate of Environmental Information and Education, with the support of the General Directorate of Citizen Participation. The Office for Climate Change was further instructed to document, release and distribute the decisions finally reached.

Figure 4 shows the organisational structure of the Spanish agricultural water administration, including the recent institutional innovations described above.

Figure 4: Agriculture-related adaptation initiatives taken by Spain's water administration



Source: Author's own compilation

7 California, United States of America

7.1 Hydrological trends and agricultural production in California

The IPCC has identified California as being exceedingly vulnerable to disruptive effects of climate change and, above all, to frequent droughts resulting from a severe change of precipitation patterns and rising temperatures (IPCC 2007). By 2050, up to 40 per cent of the Sierra snow pack may disappear, resulting in decreased runoff, which will impact on water supply for urban, agricultural and environmental uses (Government of California 2009b). California not only represents a hot spot of climate change: it also includes some of the most important areas of agricultural and horticultural production in the USA. According to the California Department of Food and Agriculture, nine of the top ten agricultural producing counties of the USA are located in California (California Department of Food and Agriculture 2009). In 2007, California farmers generated US$ 36.6 billion, equivalent to 12.8 per cent of the total national agricultural output that year (ibid.).

7.2 Organisational structure of California's agricultural water administration

The American federal system has led to considerable organisational diversity in water administration. The allocation of water in the USA is mostly a matter of state law. In the course of American history, the 50 states have developed various types of property rights regimes, often representing a "dual system", which combines private and public property (Dellapenna 2009, 180).

Responsibilities and authority relating to water in California are not held exclusively by the state government (Blomquist et al. 2004, 57 ff.), but are characterised by a high degree of polycentricism. Within the state government several agencies have water management responsibilities, and at local level water management functions are performed by a large number of local authorities, including hundreds of counties and municipalities, thousands of special districts and dozens of joint-power authorities (ibid.), together with self-organised non-profit Irrigation Districts (see below).

California water law recognises separate bases for establishing rights to the use of groundwater and surface water. The existence of these alternative systems adds considerable uncertainty to water development and management efforts (Blomquist et al. 2004, 58). Surface water rights are recognised either on the basis of riparian rights or the doctrine of prior appropriation. Riparian water rights are rights of landowners to use the flow of a river that crosses or borders their land. As these riparian rights are not quantified, they are not governed by a permit process (ibid.). Riparian rights are limited by the doctrine of "reasonable and beneficial use". The doctrine of prior appropriation, on the other hand, awards water rights on the basis of diversion from the stream or water body and actual use, and establishes priority of senior use rights (ibid.).

Exceptions and limitations are (i) pueblo *water rights* granted under Spanish colonial rule and still held by a number of communities; (ii) the *public trust* doctrine and *public nuisance*, both of which basically serve to limit water diversions and uses that threaten publicly held values; and (iii) the operation of *large-scale water projects*, such as the State Water Project, which will be briefly discussed below. Wherever they exist, these exceptions are treated as superior to any riparian or appropriative right claims. Groundwater use rights are recognised and allocated in accordance with a highly complex set of often multifaceted and overlapping rules.[27]

California's legal system is such that decisions on water withdrawal, distribution and use are taken by largely autonomous and independent local level agencies. In total, some 600 of these special-purpose local organisations provide California customers with water (Water Education Foundation 2009). Local-level agencies in the field of agricultural water management are historically known as Irrigation Districts.[28] Many of them hold property rights to water under the provisions of California water law (Blomquist et al. 2004). Irrigation Districts, whose establishment dates back as far as the Wright Act of 1897 and the California Irrigation District Act of 1917, are self-organised, non-profit bodies, which of-

27 For a more comprehensive discussion of Californian surface and groundwater law see Blomquist et al. (2004, 60 ff.).

28 For historical reasons, the term "irrigation district" in fact denotes water agencies that specialise in the supply of water to farmers.

ten operate as contractors to the California Department of Water Resources (DWR) and the US Bureau of Reclamation (Scheumann 2005).

The responsibilities of the state government and its water agencies are in many instances restricted to the regulation of water quality, the submission of recommendations for good governance, the provision of technical assistance and the allocation of funding opportunities. However, federal-level and state-level water agencies, such as the US Bureau of Reclamation, the US Army Corps of Engineers and the DWR also play important roles in the planning, funding and operation of large-scale cross-regional water systems. The US Bureau of Reclamation and the US Army Corps of Engineers are both heavily involved in the planning, construction and maintenance of large dams and canals. The US Bureau of Reclamation, the DWR, the California State Water Resources Control Board and the California Regional Water Quality Control Board are involved in the management of irrigation and drainage systems and in water pollution control (Scheumann 2005).

The DWR operates the State Water Project, which is one of the world's largest public water conveyance systems, currently supplying over 23 million people and about 302,000 hectares of irrigated farmland (California Department of Water Resources 2009a). Local Irrigation Districts play only a limited role in managing large-scale water systems, since they receive their water as contractors of the DWR. The Irrigation Districts receive the contracted amount of water, which is then distributed to the District's members, who are mainly farmers. In turn, Irrigation Districts have the right to sell bonds and to raise fees and taxes (Scheumann 2005).

7.3 Institutional initiatives in California's water governance

As a consequence of California's highly decentralised water governance system, initiatives are often taken in a spontaneous and uncoordinated manner by individual local agencies. In recent years, however, California water agencies have also tended to collaborate more closely vertically and horizontally. Many of these so-called collaborative planning groups have put forward new ideas for adaptive water governance. A range of noteworthy examples can be found in the context of the implementation of the California Global Warming Solutions Act of 2006 (AB32) and the ongoing California Integrated Water Resources Management Program.

The following sections provide an in-depth description of two collaborative planning processes: (i) the Climate Action Team (CAT), which primarily represents macro-level horizontal collaboration, and (ii) the establishment of the Upper Kings Water Forum and its engagement in fostering formal institutional change through the creation of the Integrated Water Resources Management Plan for the Upper Kings River Basin. This Water Forum is an example of long-term local horizontal and, more recently, vertical collaboration. The introduction of climate-proofing criteria into regional funding application schemes is considered to be a third instructive institutional initiative.

7.3.1 The Climate Action Team

In 2005, the California government set aggressive greenhouse gas reduction targets – 1990 levels by 2020 – which were signed into law in 2007 (AB32). As part of this policy, the California Environmental Protection Agency was directed to initiate and lead a cross-agency, interdisciplinary working group known as the CAT,[29] which comprises 14 macro-level agencies and has been assigned to coordinate California's policies on the mitigation of and adaptation to climate change. It is also responsible for reporting on progress towards meeting the targets set in AB32. Annual reports were published regularly between 2006 and 2009.

Specific, sector-related initiatives and strategies are developed and propagated through 11 thematic subgroups, namely (1) economics; (2) cement; (3) agriculture; (4) water/energy; (5) forestry; (6) recycling; (7) scenarios; (8) state fleet; (9) green building; (10) energy; and (11) land use. These subgroups consist of experts from appropriate state agencies. Three of them, namely water/energy, agriculture and land use, are directly concerned with climate change-induced water scarcity and its effects on agricultural water management. The Subgroup on Water/Energy (WET CAT) is, for instance, chaired by the California Department of Water Resources and comprises staff from sixteen other state agencies.

All thematic subgroups engage in vertical collaboration with stakeholders from potentially affected sectors, including irrigated agriculture. They hold regular meetings and stakeholder workshops, publish assessment reports and draw up recommendations for specific measures to be taken.

The California government further strengthened its commitment to managing the impacts of climate change when the Governor's Executive Order S-13-2008 was signed on 14 November 2008. The order called on the California Resources Agency, through the Climate Action Team, to coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy by summer 2009. The strategy, which was finalised in September 2009, summarises the current state of scientific knowledge on climate change impacts and proposes a set of recommendations designed to inform and guide California decision-makers as they begin to develop adaptive policies. The recommendations are to be implemented within and across state agencies to promote resilience.

Agricultural water management is a major theme and therefore the Action Team accordingly assess the effects of climate change on California's water balance and assume that they will become highly significant for the agricultural sector, the reasons being an expected increase in evapotranspiration of crops, a moisture deficit in non-irrigated agriculture, increased irrigation needs because of a protracted growing season and, last but not least, growing urban demand, potentially at the expense of agricultural water use (Government of California 2009b). The document rejects a "one size fits all approach" and in-

29 Based on Executive Order S-3-05 on 6 January 2005, which instructed the Secretary of the California Environmental Protection Agency to coordinate with the Secretary of the Business, Transportation and Housing Agency; the Secretary of the Department of Food and Agriculture; the Secretary of the Resources Agency; the Chairperson of the Air Resources Board; the Chairperson of the Energy Commission; and the President of the Public Utilities Commission.

stead proposes an array of adaptive strategies to better address the risks and uncertainties (ibid., 86).

In collaboration with the State Water Resources Control Board and other agencies, the DWR has reacted to this assessment by initiating a number of projects on climate change adaptation planning for the water sector, mainly in the context of the California Water Plan Update 2009 and the ongoing facilitation of Integrated Water Resources Management (ibid.).

More concrete recommendations are for an aggressive increase in water use efficiency, mainly by encouraging agricultural entities to apply Efficient Water Management Practices (EWMPs). Such EWMPs could, for instance, seek to reduce water demand and improve the quality of drainage and return flows. The strategy emphasises that the most promising EWMPs are those that reduce evaporation from the land, crop evapotranspiration, other consumptive uses, flows to saline sinks (e. g. the ocean), etc.

This set of "near-term" measures thus focuses on water conservation and includes the goal of expanding the collection and dissemination of local weather information for irrigation planning; an increase in support for water stewardship practices, either through the expansion of the role of mobile irrigation laboratories or through other services provided by Resource Conservation Districts, Water or Irrigation Districts and Cooperative Extension services; support for the expansion of voluntary district-level water conservation plans for all agricultural water districts; the prioritisation and expansion of technical and financial cost-share assistance programmes for growers; investment in new uses for saline drainage water, using renewable solar and on-farm bio-fuel energy sources to treat saline water; the design of water-pricing systems that reward conservation and the streamlining of regulations requiring agricultural water users voluntarily to make more water available for other beneficial uses through water transfers; and the provision of marketing support for dry farming (Government of California 2009b).

Actions to be taken in the long term are the facilitation of research on drought-tolerant crops and the development of response strategies to address severe droughts; the improvement of water reliability and support for research on practices to promote the water-holding capacity of soils (Government of California 2009b).

7.3.2 The Upper Kings Water Forum and the Upper Kings IWRM Plan

Local-level initiatives aimed at climate change adaptation are part of a general trend towards the introduction of Integrated Water Resources Management (IWRM).[30] At present, various local collaborative planning groups are devoted to establishing and introducing

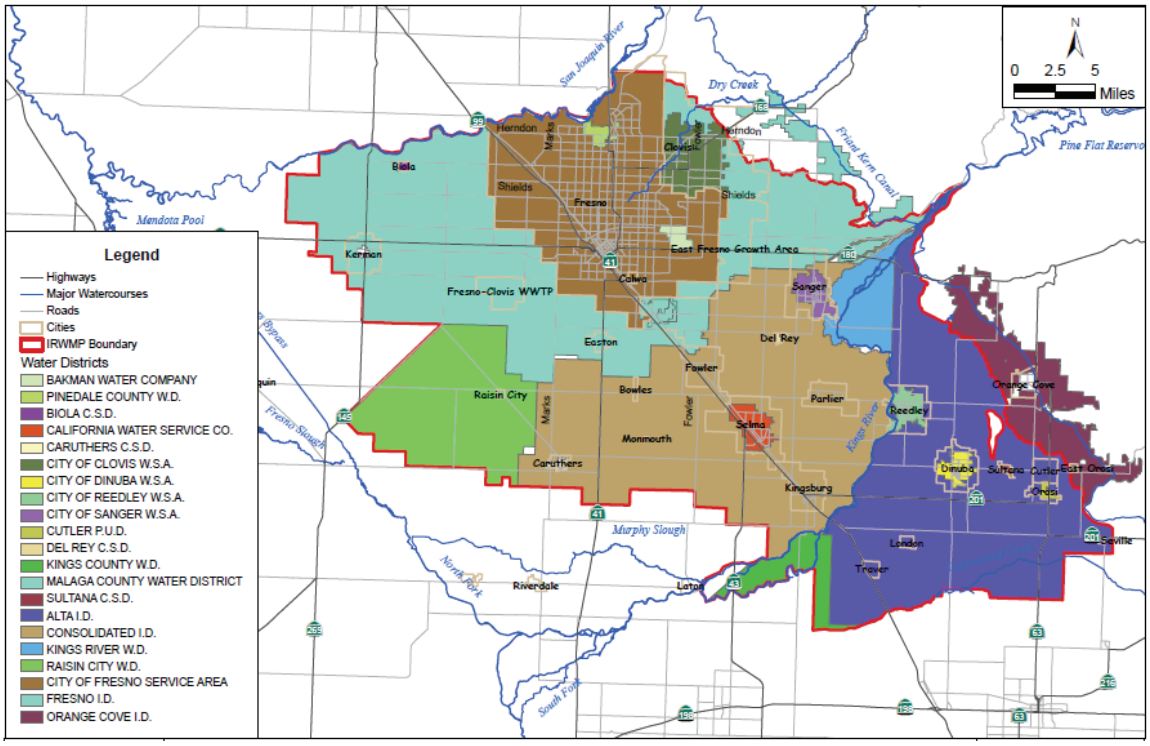
30 Huppert (2005) examines various definitions of IWRM, but highlights a cross-sectoral definition suggested by Global Water Partnership (2000): "IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." IWRM therefore involves a quest to "balance" the water demand of many sectors. The idea of sustainability is given priority. The key element is an ecosystem approach to watershed planning that permits the consideration of material cycles and the participative inclusion of different interests of the various sectors and groups of the population (Neubert et al. 2005, 17).

IWRM within their jurisdictions. Such stakeholders as irrigation districts, municipal water agencies, energy producers and private entities participate, the number in each case depending on the size of the watershed area.

A noteworthy example of an innovative initiative that evolved in the course of simultaneous horizontal and, more recently, vertical collaboration is the development of the Upper Kings IWRM Plan. The Upper Kings Basin is located in California's Central Valley, one of the state's most important agricultural regions. Fresno County, which covers a considerable part of the basin, produces more than US$ 5 billion of produce, making it the most productive county in the state (California Department of Food and Agriculture 2009). In recent years, the Central Valley has also been characterised by high rates of land conversion and urbanisation. Both irrigated agriculture and urbanisation impose severe pressures on the basin's water resources. As a consequence, there has been a continuous groundwater overdraft.[31]

Figure 5 shows the boundaries of the Upper Kings Basin and the cities and communities which derive their water from it. The map also indicates the multitude of participating local water agencies and their respective jurisdictions. The boundaries of the present IWRM plan are shown in red.

Figure 5: Stakeholders in the Upper Kings Basin covered by the IWRM plan



Source: WRIME (2007)

31 The average annual groundwater overdraft has been calculated at approximately 18.5 million cubic metres (WRIME 2007).

Most of the non-urban areas within the Upper Kings Basin are under intensive irrigated agriculture. Water provision within the Upper Kings River Basin is the responsibility of more than twenty independent local-level agencies, including three large irrigation districts, county water departments, city water departments and a number of private corporations (see Figure 5). In the past, local water agencies in the basin tended to organise water allocation individually and without consideration for potential externalities in the territories of neighbouring agencies. This behaviour has been changing slowly as awareness of the complex hydrological interactions of the resource system has grown.

An early horizontal collaborative initiative was launched in 2001. Four comparatively large local water agencies, namely the Kings River Conservation District, the Alta Irrigation District, the Consolidated Irrigation District and the Fresno Irrigation District, formed a Basin Advisory Panel (BAP). The members of the BAP sought technical and financial support from the DWR and signed a memorandum of understanding. They made "*significant progress by working together to define the water resources problems but realized that the involvement of other stakeholders in the basin would be necessary*" (WRIME 2007, 2). The BAP members solicited wider stakeholder participation until, in 2004, the Upper Kings Water Forum was formed. The Water Forum today comprises 34 member organisations, including local water agencies, representatives of cities and municipalities, research organisations and environmental interest groups. The DWR, the California Department of Fish & Game and the Regional Water Resources Control Board are also represented in the Forum.

In early 2005, the Water Forum embarked on the development of an Integrated Regional Water Management Plan in order to "*improve water management, reduce conflicts, protect water quality, and ensure sustainable resources management through regional cooperation*" (WRIME 2007, 3). The development of the IWRM Plan included the completion of a wide range of technical studies, the preparation of briefings and technical memoranda, the design of a surface water model, a community affairs process and meetings among various work groups and Water Forum participants (ibid.). After two years of preparation the Upper Kings IWRM Plan was finalised and submitted to the DWR with a request for funding from the IWRM Program.[32]

The Upper Kings IWRM Plan sets a planning horizon that extends until 2030. A number of goals are pursued, including (i) long-term sustainability and reliability of surface and groundwater supply; (ii) the protection of existing rights and the revision and adjustment of overlying groundwater rights and (iii) the sustainability of the agricultural economy.

Local Irrigation Districts, such as the Alta Irrigation District, the Consolidated Irrigation District and the Fresno Irrigation District, which have adopted IWRM, are confronted with a broad range of additional, often modified, tasks and mandates. Water use and development are hence no longer oriented towards the delivery of services for the local agricultural sector alone. An agency adopting IWRM instead needs to allow for a balancing of multiple, often contradictory uses, some of which may lie well outside the agency's traditional field of activity and expertise. The agency's decisions on the distribution of water to

32 To date, over US$ 11 million has been contributed to the cost of planning and expanding local groundwater projects in the region (Upper Kings Basin Integrated Regional Water Management Authority 2009).

irrigators or on investment in infrastructure must also consider – and possibly prevent – any negative externalities on such competing uses as water for food and water for nature. Within this context, the agency must consider user groups other than irrigators, such as urban and industrial water users, and environmental interest groups. Agencies highly specialised in irrigation services may undergo greater structural and institutional adjustment than those which have already been servicing a variety of sectors.[33]

The scope of watershed-wide governance, as envisioned by IWRM, also requires due consideration of potential negative externalities not only within the agency's jurisdiction, but in the watershed area as a whole. To this end, all agencies must establish cooperative linkages with each other. Agricultural water agencies must allocate considerable human and financial resources for the implementation of the IWRM Plan.

The DWR recognises IWRM as "*a critical framework for actions to address the uncertainties presented by climate change as well as other risks to California's water future*" (Government of California 2009a). The state of California therefore supports the introduction of IWRM in regional and local water management by providing funds and technical assistance. Considerable funds have already been allocated through a bond programme. Altogether, three funds[34] have provided more than US$ 5 billion of support for the implementation of IWRM projects by local and regional agencies. In 2010, California voters will be asked to decide on another US$ 11.14 billion bond issue for future IWRM projects.[35]

7.3.3 New funding schemes include adaptation criteria

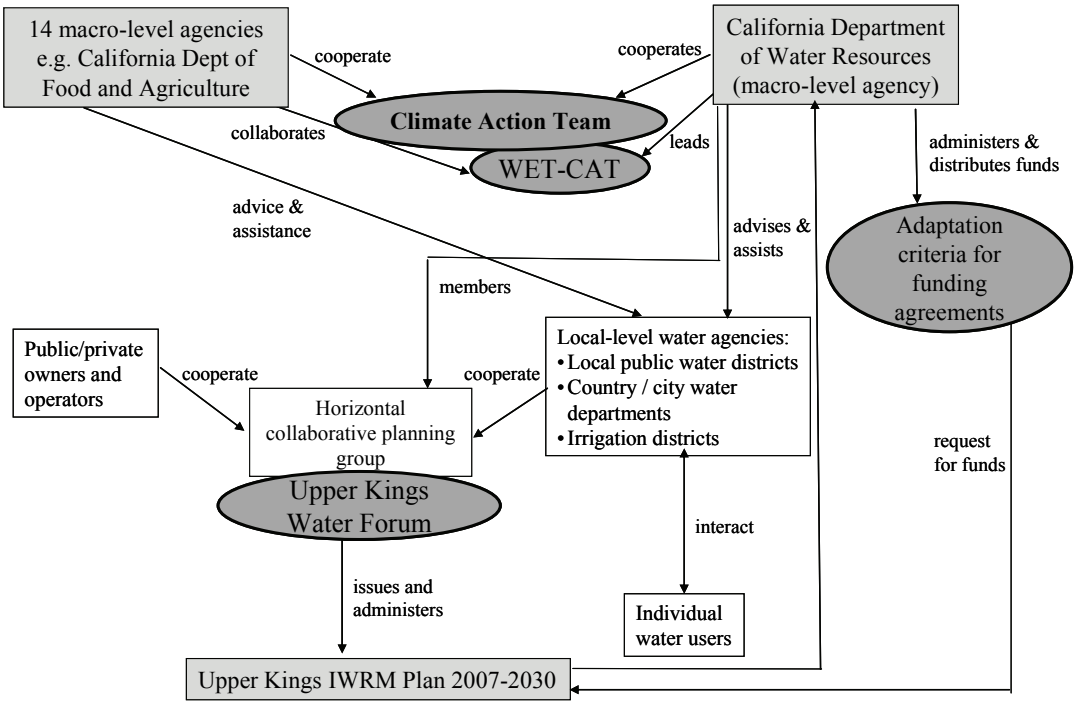
The DWR, which is responsible for administering and allocating financial resources, requires every applicant to undergo an approval process before it submits an application. As part of this application process, a regional IWRM plan has to be submitted. The actual development and design of each IWRM plan are based on the independent commitment of the participating local water agencies. The DWR has, however, set specific criteria to be applied in the evaluation of every IWRM plan to ensure that it conforms to California water legislation, the grant programme concerned and the current version of the California Water Plan. The introduction of adaptation criteria into funding application schemes is considered a remarkable third institutional initiative.

33 In fact, many California Irrigation Districts initially established for the sole purpose of servicing farmers today service a variety of sectors. One reason for this development has been the major increase in the population of California and the simultaneous growth of urban areas over the past century. We pointed to this ongoing trend earlier when discussing recent structural changes in the Central Valley.

34 These funds are governed by the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 (Proposition 50); the Disaster Preparedness and Flood Prevention Bond Act of 2006; and, most recently, the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Act of 2006 (Proposition 84).

35 In 2008, the DWR and the Resource Agency jointly proposed the allocation of more reliable – that is, not market-driven – funding sources in addition to existing bond programmes (Government of California 2008b).

Figure 6: Agriculture-related adaptation initiatives in California's water administration



Source: Authors' own compilation

Consequently, the DWR has hitherto preferred, but not formally required, any such measure to be included in an application. From 2011, however, it is envisaged that all IRWM plans will include specific measures for climate change adaptation. All applicants will then have to: (i) submit an assessment of the region's vulnerability to the increased long-term risks; (ii) provide for the integration of a flood management component; and (iii) include a drought component that assumes a 20 per cent increase in the frequency and duration of future dry conditions (Government of California 2009a).

Figure 6 shows the organisational structure of California's agricultural water administration, including the recent institutional innovations described above.

8 Conclusion

Looking at processes of institutional change in Germany, Spain and the USA, we realized that a variety of drivers are at work: perceptions of predicted climate change impacts; international obligations forcing politicians to take action; socio-economic concerns such as the cost of not taking action; the economic interests of the private sector. Drivers are manifold and often interact and, in many cases, reforms in the water sector may be driven by and associated with a larger reform agenda.

Our first assumption has been that the degree of planned and anticipatory top-down implementation decreases if actions are more decentralized and are introduced at the regional or local level; the second assumption relates to the degree of autonomous and responsive adaptation approaches which seems to grow with actions at a lower administrative scale.

8.1 At a glance: institutional adaptation to climate change

The three cases presented show that policy-makers and, in particular, water agencies at different administrative levels have initiated and introduced a variety of institutional adaptations to prepare agriculture for climate change-induced threats.

At national level, both Germany and Spain have developed overarching national adaptation strategies, which also address the agricultural water sector. The German and Spanish NASs both provide for nation-wide assessments of expected impacts of climate change. Germany's NAS places specific emphasis on vulnerabilities and potential measures in the area of agricultural land and water management. The Spanish NAS, which makes a less clear distinction, gives the agricultural water sector a high priority as regards the activities that should be undertaken. Both NASs serve as general frameworks for the guidance of lower-level administrative organs of the respective states, regions or municipalities, which are therefore invited to comment on the NAS findings and propositions. They are further prompted to ask for federal assistance with the development of their own approaches. The United States has not yet adopted a National Adaptation Strategy. So far, only individual states, such as California, have attempted this. However, a range of nationwide policy efforts are being made and – if signed into legislation – will have a strong impact on agricultural water governance and management.

All the cases presented here represent a number of institutional adaptations at lower administrative levels to meet climate change-induced challenges in the agricultural sector:

For Brandenburg in Germany we have highlighted three such adaptations: first, the bottom-up initiative to re-establish a drainage advisory board to operate the infrastructure needed for water retention; second, the establishment of the Working Group on the "Landscape Water Regime", this being an interdisciplinary cross-agency team; and third, the empowerment of Brandenburg's water and soil associations to design their own projects, for which they may receive financial support from a newly established fund.

The Spanish agricultural water administration has launched the ALBERCA programme, a remarkable nation-wide programme for the registration of (ground)water rights. This might be seen as a prerequisite for larger reforms in the agricultural water sector, since clearly defined and transparent water rights are essential for sustainable resource management. Furthermore, the Ebro River Basin Organisation has proactively developed the Ebro Drought Plan as a supplement to the Ebro River Basin Management Plan. A third initiative for coping with climate change was driven by the regional government of the Autonomous Community of Catalonia, which introduced a regional strategy based on broad stakeholder involvement – leading to what is known as the Catalonian Convention on Climate Change.

Owing to the decentralised and polycentric nature of California's governance system, most decisions on water withdrawal and distribution are taken by a vast number of independent local-level agencies. However, as in Germany and Spain, California water agencies have been engaging in vertical and horizontal collaboration. The Climate Action Team was presented as a form of horizontal collaboration in a macro-level institution which develops sector-related measures and strategies and is increasingly engaging in vertical collaboration and stakeholder involvement. The second example is the establishment of the Upper

Kings Water Forum, which embraces 34 member organisations and has been engaged in the creation of the Upper Kings IWRM Plan. Finally, a third climate change-induced institutional approach is the introduction of adaptation criteria into regional funding schemes.

The patterns in adapting agricultural water governance can be subsumed as follows:

1) Interdisciplinary cross-agency working groups have been established by decree. Some are more horizontal/inter-sectoral (Working Group on the "Landscape Water Regime" in Brandenburg), others are also vertical, i.e. they cover different hierarchical levels of water administrations (Upper Kings Water Forum in California).
2) Adaptation criteria for funding schemes serve as incentives for local organisations, which may initiate their own projects (the water and soil associations in Brandenburg, the Ebro Drought Plan in Spain and the Upper Kings IWRM Plan in California).

Paavola and Adger (2006) have stressed the need for broad social inclusion – through vertical collaboration – owing to the multi-scale dimension of climate change. It is particularly worth noting that (i) liaison between one branch of administration and relevant other branches and (ii) not only horizontal but also vertical cooperation are required when the *precautionary principle* (UNESCO 2005, 39) and Integrated and Adaptive Water Management are put into practice. Such initiatives are facilitating knowledge transfer and learning, and they increase coherence.

However, a serious administrative problem that such collaborative initiatives have in common is what is known as the *problem of interplay.* The problem of interplay predominantly occurs whenever vertical interaction of the political and administrative hierarchy at national, federal and regional (German *Land* or US state) level and horizontal interaction across different sectoral units and organisations (e. g. spatial planning, agriculture, sanitation, water management, disaster management are required (Young 2002; Moss 2003). When different authorities need to collaborate, ambiguity is frequently encountered in the definition of their respective central and local responsibilities. In essence, the central level often tries to retain control over local decision-making. Introducing new forms of cooperation and platforms for knowledge transfer (e. g. the Climate Action Team, Working Group on the "Landscape Water Regime") could be one element in reducing these ambiguities and fostering the interplay of administrative units at different levels and across different sectors.

8.2 Drivers of the adaptation of agricultural water governance

In all cases and across all levels, a mix of ecological and political drivers is at work triggering institutional adaptation. However, in line with our earlier assumption (cf. Figure 1), this mix has turned out to differ as a function of the level of the administrative setting. At the higher level political drivers (e. g. international commitments) have played a more prominent role. The German and Spanish cases are examples of global policies, in fact, boosting national policy design and implementation. The UNFCCC's role in fostering NAS even leads to the conclusion that global policies have provided new political and financial tools for enhancing adaptive capacities. At lower levels the impact of ecological drivers, such as the experience of weather extremes, is more pronounced.

Like Adger et al. (2007), our study indicates that water agencies seldom take initiatives in response to climate change forecasts alone, but similarly react to extreme weather events. Nevertheless, the agricultural sector's vulnerability to climate change has been one driver of the adaptation of agricultural water governance where the agricultural sector is of economic (and eventually political) relevance.

At higher political levels, initiating coordination across agencies with a view to their including climate change issues in their agendas dominates, while lower levels are more concerned with developing rules and procedures that facilitate the implementation of technical solutions to coping with actual climate-induced impacts.

As regards the drivers of regional and local initiatives, a mix of climate and non-climate-related factors can again be observed. In Brandenburg, the bottom-up re-establishment of the drainage advisory board was driven by increased awareness of water retention problems in the area and long-term climate change scenarios indicating an increase in summer droughts, whereas the establishment of the Working Group on the "Landscape Water Regime" was clearly driven by an extreme event, namely the drought in 2000.

In Spain, the need for more accurate data on groundwater quality and groundwater withdrawal was a major driver of the nationwide ALBERCA programme launched by the Ministry of Environment. EU policies require such a registry as a knowledge base to enable environmental standards to be met. Secure property rights are also expected to have a positive economic impact. The Ebro Drought Plan, a regional initiative, was prompted by persistent drought problems in the region and by climate-change forecasts of more frequent droughts. NGOs also participated in and were a major contributor to the elaboration of the plan. The Catalonian regional strategy for coping with climate change refers to the Kyoto Protocol, thus demonstrating that commitments to international agreements drive actions at not only national but also regional level. The gathering of opinions held by the public for the final draft of the Convention was a result of public environmental awareness and indicates that the media and NGOs played a major role.

A top-down administrative order of the California Environmental Protection Agency led to the establishment of California's Climate Action Team (CAT) to meet the requirements associated with environmental policy targets. It is to coordinate California's policies on the mitigation of and adaptation to climate change. Climate scenarios, particularly the predicted effects on California's water balance, have led to recommendations by the DWR, for example, for adapting agricultural water governance to increase water use efficiency. The *Economist* recently stressed that keeping people employed in the agricultural sector is a valid incentive for the government to take action. Demographic trends (in particular, the doubling of California's population in the next 40 years plus further immigrants looking for work) combined with the expected water shortage is causing serious concern (The Economist 2010). The case of California therefore underscores our earlier observation that adaptation to climate change is often embedded in a broader agenda, which simultaneously pursues a number of water-related goals. The trend for IWRM is – again in analogy with our earlier discussion – driven by the concurrence and interaction of a multitude of drivers, including repeated events of drought and flooding;[36] increasing public awareness

36 The DWR refers to 2009 as being the third consecutive year of drought in California (California Department of Water Resources 2009b).

of environmental issues;[37] and the conviction that those problems require coordination across administrative boundaries. Climate change adaptation measures under the Upper Kings IWRM Plan are just one of a number of tasks that have to be performed.[38] Besides the impacts on irrigated agriculture, urbanisation is often seen as imposing serious pressure on a basin's water resources. Both the establishment of the Upper Kings Water Forum and the development of the Upper Kings IWRM Plan have been characterised by broad stakeholder involvement. This in turn is possible only where there is a certain level of public environmental awareness, which is driven by the media and NGOs.

Administrative bodies of the agricultural water sector are understood as organizations with inherent institutional arrangements (rules). Drivers for adaptation to climate change may be attributed to the outside, but also to the inside of an organization.[39] *Internal organizational resistance* by employees can be caused by many reasons one being the fear of losing power due to organizational change. One concept explaining internal organizational resistance is administrative inertia. It is due, inter alia, to high transaction costs faced by civil servants (time, meetings, memos, etc.) in the process of familiarizing themselves with new policies and creating new procedures for implementing, e. g. participatory methods (Theesfeld et al. 2010). *Path dependency*, meaning that available alternatives are limited through institutions and ideologies of the past, is another important concept to explain the procedures going along with institutional change.

In line with the classification of adaptation used by Horstmann (2008, 26), empirical evidence contained in the case studies investigated shows that governmental actors and the public at large are more likely to initiate *planned* institutional adaptation. This is not to say that actors at local level are not able to engage in planned, anticipatory adaptation measures. Yet the cases presented show that planned, anticipatory activities tend to be undertaken at the higher administrative levels. One reason for this may be that local users have limited access to scientific knowledge (Andersson / Ostrom 2008) and may therefore be prevented from recognising the need for precautionary measures. However, local actors' knowledge and experience can provide timely signals of the need for change, which requires functioning bottom-up linkages to attract the attention of policy-makers (Ifejika Speranza et al. 2009).

Planned adaptation is often interpreted as a result of deliberate policy decisions. If commitments to international agreements drive national strategies, intentional, planned, anticipatory, proactive, long-term and strategic adaptation is more likely. The UNFCCC for instance, requires all parties to address adaptation in a precautionary and strategic way and to adopt anticipatory and planned adaptation measures (Verheyen 2002, 131). Yet, as far

37 Environmental interest groups have been demanding a shift towards ecologically sound water utilisation since at least the early 1980s.

38 The San Diego Integrated Regional Water Management Plan of 2007 serves as an example in this regard, since it identifies climate change as one of various factors leading to a future aggravation of water shortage. The San Diego County Water Authority, the City of San Diego and the County of San Diego, which developed the plan, have defined the objective as being to tackle climate change-induced water scarcity by developing a diversified mix of water supplies in the region (http://www.rmc water.com/clients/sdirwmp/plan.html; accessed 6 Dec. 2010).

39 Organization Theory (Bea / Göbel 1999) helps in understanding internal hampering factors of change in any organization.

as initiatives at local level are concerned, adaptation seems to be autonomous, spontaneous, reactive and limited to the short term (see Figure 1).

Table 2 gives an overview of the institutional adaptation explored in the various cases and its main drivers.

8.3 The way forward

This study has been carried out as a first step in determining what kind of initiatives have been taken, by whom and at what level; the driving forces behind the institutional adaptation of agricultural water governance; and how the process has been organised and encouraged. It has, however, not focused on the respective outcomes of these initiatives and processes. Although its aim was to gain useful insights (see 8.1 and 8.2), the study was designed neither to investigate 'best practices' nor to learn generalised lessons from a comparison of a few initiatives.

However, it may help to shape in-depth studies to be conducted in developing countries and also contribute to the development of pro-active strategies. From the viewpoint of development cooperation some aspects are particularly relevant and should be considered with care:

- While commitments to international regimes drive changes in agricultural water governance, national incentive schemes are nevertheless important in stimulating adaptation.
- The drivers in a given country may be manifold, or a mix of all of them, whether political or ecological/climate or non-climate, may serve as a starting point for initiating change.
- The identification of driving forces and the reactions they induce at the various administrative levels is important when it comes to deciding with whom to ally and cooperate in inducing changes in agricultural water governance.
- As institutional change is path-dependent, meaning available alternatives are limited through institutions and ideologies of the past, it may limit adaptation strategies to climate change. Proposing and initiating new governance modes of adapting agricultural water management in developing countries needs to recognise and start from country-specific conditions.
- Institutional change addresses organizations with inherent institutional arrangements. Internal organizational resistance by employees can be explained by the concepts of administrative inertia. The high transaction costs faced by civil servants (time, meetings, memos, etc.) in the process of familiarizing themselves with new policies and new implementation procedures, e. g. participatory methods has to be considered as a hampering factor for change.

Table 2: Synopsis of selected institutional adaptations, and their drivers

Country / Region	Institutional adaptation	Major drivers facilitating institutional adaptation
Germany / Brandenburg	The German NAS (2008) proclaims the development of vulnerability indicators and a national monitoring system. An inter-ministerial working group is announced. Regional/local: – Bottom-up re-establishment of drainage advisory boards – Interdisciplinary and cross-agency Working Group on the "Landscape Water Regime" – Funding program and empowerment of Water and Soil Associations	National: – Commitment to UNFCCC regime / regional integration (EU policies) – Growing evidence of climate change Regional/local: – Major drought in 2000 and economic losses to agriculture – Increased awareness of water retention problems – Climate change scenarios forecasting summer droughts
Spain / Ebro River, Catalonian region	The Spanish NAS (2006) regards water and agriculture as high priority sectors Regional/local: – National programme for the registration of water rights – Ebro River Basin Organisation develops the Ebro Drought Plan – Regional adaptation strategy in Catalonia	National: – Commitment to UNFCCC regime / regional integration (EU policies) – Growing evidence of climate change – Creation of database as prerequisite for governance/management – Expected positive economic and ecological effects Regional/local: – Actual drought problems and economic losses to agriculture; – Climate change scenarios forecasting summer droughts – Public environmental awareness (associated with the role of NGOs and the media)
USA / California, Upper Kings Basin	State of California adopts AB 32 and publishes Climate Adaptation Strategy (2009) Regional/local: – Climate Action Team – Upper Kings Water Forum and the development of the Upper Kings IWRM Plan – Recognition of adaptation criteria for regional funding schemes	State level: – Environmental policy requirements – Climate change scenarios forecasting summer droughts Regional/local: – Growing demand for water, population growth, urbanisation, migration – Lack of employment opportunities outside agriculture – Repeated experience of weather extremes – Public awareness (associated with the role of NGOs and the media)

Source: Author's own compilation

— There is some evidence that decentralised systems react adequately to local environmental shocks or damage. However, they need to be sufficiently 'equipped' with human and financial resources and supported with resources provided by central decision-making levels (i.e. financial incentives).

— Agricultural water (and land) systems are diverse and complex ecological systems requiring context-specific solutions and advice. However, it is sufficiently evident even from the three cases presented that there are similar trends of institutional adaptation and that they are specific to a region's political, administrative, economic and ecological situation. A blueprint cannot be provided, then, only context-specific advice.

— Finally, it is a matter of concern how the process of adapting agricultural water governance to climate change is framed, and in particular, how to link bottom-up to top-down initiatives and *vice versa*.

Bibliography

Adger, W. N. et al. (2007): Assessment of adaptation practices, options, constraints and capacity, Climate change 2007: Impacts, adaptation and vulnerability, in: M. Parry et al. (eds.), Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, UK: Cambridge University Press, 717–743

Adger, W. / N. Arnell / E. Tompkins (2005): Successful adaptation to climate change across scales, in: *Global Environmental Change* 15 (2), 77–86

Allio, L. et al. (1997): Post-communist privatization as a test of theories of institutional change, in: D. L. Weimer (ed.), The political economy of property rights, Cambridge: Cambridge University Press, 319–348

Andersson, K. / E. Ostrom (2008): Analyzing decentralized resource regimes from a polycentric perspective, in: *Policy Sciences* 41, 71–93

Aubin, D. / F. Varone (2004): The evolution of European water policy, in: S. Kuks / I. Kissling-Näf (eds.): The evolution of national water regimes in Europe, Transitions in water rights and water policies, Dordrecht, Boston, London: Kluwer Academic Publishers

Bakkes, J. et al. (2006): Cost of policy inaction, Scoping study for DG environment, Netherlands: Environmental Assessment Agency

Bea, F. / E. Göbel (1999): Organisation, Theorie und Gestaltung, Stuttgart: Lucius und Lucius

Blomquist, W. / E. Schlager / T. Heikkila (2004): Common waters, diverging streams: Linking institutions to water management in Arizona, California and Colorado, Washington, DC: RFF Press

Braune, E. / Y. Xu (2009): The role of ground water in sub-Saharan Africa, in: *Ground Water,* doi: 10.1111/j. 1745-6584.2009.00557.x

Bromley, D. (1989): Economic interests and institutions: The conceptual foundations of public policy, Oxford, Cambridge: Basil Backwell

California Department of Food and Agriculture (2009): California agricultural highlights brochure 2008–2009; online: http://www.cdfa.ca.gov/statistics/files/AgHighlightsBrochure (accessed 2 Dec. 2009)

California Department of Water Resources (2009a): online: http://www.water.ca.gov/nav/nav.cfm?loc=t&id=102 (accessed 10 Dec. 2009)

– (2009b): online: http://www.water.ca.gov/drought (accessed 7 Dec. 2009)

Climate Science Watch (2009): online: http://www.climatesciencewatch.org/index.php/csw/C28 (accessed 7 Dec. 2009)

Costeja, M. et al. (2004): The evolution of the water regime in Spain, in: S. Kuks / I. Kissling-Näf (eds.), The evolution of national water regimes in Europe, Transitions in water rights and water policies, Dordrecht, Boston, London: Kluwer Academic Publishers

Dähne, C. (2000): Spanisches und deutsches Wasserrecht, Ein Vergleich, in: M. Bothe / E. Rehbinder / R. Steinberg (eds.), Frankfurter Schriften zum Umweltrecht, Baden-Baden: Nomos, 22

Dellapenna, J. (2009): United States: The allocation of surface waters, in: J. Dellapenna / J. Gupta (eds.), The evolution of the law and politics of water, Dordrecht: Springer

Dinar, A. (2001): Reforming ourselves rather than our water resources, Politics of water scarcity at local, national and international levels, Bonn: Deutsches Institut für Entwicklungspolitik

Ebro Hydrographic Confederation (2009): online: http://www.chebro.es (accessed 8 Dec. 2009)

Eggertson, T. (1990): Economic behavior and institutions, Cambridge: Cambridge University Press

EU (European Union) (2000): Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, in: *Official Journal of the European Union* L 327, 22/12/2000

– (2007a): Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, in: *Official Journal of the European Union* L 288/34, 6/11/2007

– (2007b): Green Paper from the Commission of the European Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Adapting to climate change in Europe – options for EU action, COM (2007) 354 final 29/6/2007, Brussels

– (2009a): White Paper – Adapting to climate change: Towards a European framework for action, COM (2009) 147 final 1/4/2009, Brussels

– (2009b): Adapting to climate change: the challenge for European agriculture and rural areas, Commission staff working document accompanying the White Paper: Adapting to climate change: towards a European Framework for action, SEC (2009) 417, Brussels

– (2009c): Climate change and water, coasts and marine issues, Commission staff working document accompanying the White Paper: Adapting to climate change: towards a European framework for action, SEC (2009) 385, 22/7/2009, Brussels

FENACORE (Federación Nacional de Comunidades de Regantes de España) (2010): Las Comunidades de Regantes de España y su Federación Nacional; online: http//:www.fenacore.org/empresas/fenacore/documentos/espanol.doc (accessed 25 Feb. 2010)

Ferrer, J. et al. (2004): El proyecto ALBERCA como ejercicio de modernización y coordinación entre administraciones, Actas del II Congreso Internacional de Ingeniería Civil, territorio y medio ambiente, Santiago de Compostela: Grupo III – La Gestión del Agua, Tomo II, 975–986

Folke, C. et al. (2005): Adaptive governance of social-ecological systems, in: *Annual Review of Environment and Resources* 30, 441–473

Garduño, H. et al. (2002–2006): Ground water abstraction rights, Briefing note series sustainable ground water management, 5, Washington, DC: World Bank

Generalitat de Catalunya (2009): online: http://www.gencat.cat (accessed 7 Dec. 2009)

German Government (2008): Deutsche Anpassungsstrategie an den Klimawandel, Beschluss des Bundeskabinetts 17. Dezember 2008; online: http://www.bmu.de/klimaschutz/downloads/doc/42783. php (accessed 12 Nov. 2009)

Gerstengarbe, F. et al. (2003): Studie zur klimatischen Entwicklung im Land Brandenburg bis 2055 und deren Auswirkungen auf den Wasserhaushalt, die Forst- und Landwirtschaft sowie die Ableitung erster Perspektiven, PIK Report 83, in: F. Gerstengarbe (ed.), Potsdam: Potsdam Institut für Klimafolgenforschung

Government of California (2006): Global warming solutions Act of 2006, Assembly Bill No. 32. 27/11/2006

– (2008a): WETCAT subgroup report; online: http://www.climatechange.ca.gov/climate_action_team/ reports/index.html (accessed 6 Dec. 2009)

– (2008b): Managing an uncertain future, Climate change adaptation strategies for California's water; online: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf (accessed 3 Dec. 2009)

– (2009a): California water plan update 2009; online: http://www.waterplan.water.ca.gov/cwpu2009/ index.cfm (accessed 2 Dec. 2009)

– (2009b): 2009 California climate adaptation strategy, A report to the Governor of the State of California in response to executive order S-13-2008; online: http://www.energy.ca.gov /2009 publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.pdf (accessed 26 Feb. 2010)

GovTrack.us (2009): online: http://www.govtrack.us (accessed 5 Dec. 2009)

GWP (Global Water Partnership) (2000): Integrated water resource management, TAC Background Paper 4, SE 105 25, Stockholm

– (2009): Climate change: How can we adapt?, GWP: Briefing Note, 29 Oct. 2009

Hayek, F. v. (1964): Arten des Rationalismus, in: F. v. Hayek (1969), Gesammelte Werke von F. A. von Hayek, Freiburger Studien, 5, Tübingen: J. Mohr (P. Siebeck), 75–89

Herrfahrdt-Pähle, E. (submitted): Adaptive water governance: a conceptual approach and its application in South Africa, in: Regional Environmental Change

Horstmann, B. (2008): Framing adaptation to climate change – a challenge for building institutions, Bonn: Deutsches Institut für Entwicklungspolitik (Discussion Paper 23/2008)

Huntjens, P. et al. (2008): The role of adaptive and integrated water management (AIWM) in developing climate change adaptation strategies for dealing with floods and droughts: A formal comparative analysis of eight water management regimes in Europe, Asia and Africa, in: Institute of Environmental Systems Research (ed.), Deliverable 1.7.9b of the NeWater project, Osnabrück: University of Osnabrück

Huppert, W. (2005): Was ist IWRM? – Plädoyer für ein differenziertes Verständnis des Konzepts "Integriertes Wasserressourcen-Management", in: S. Neubert et al. (eds.), Integriertes Wasserressourcenmanagement (IWRM) – Ein Konzept in die Praxis überführen, Baden-Baden: Nomos, 15–30

Ifejika Speranza, C. et al. (2009): Indigenous knowledge in climate variability and climate change monitoring, mitigation and adaptation: Insights from droughts in semi-arid Makueni District, Kenya, Climatic change, doi: 10.1007/s10584-009-9713-0

IMA „CO_2 Reduktion" (2005): Nationales Klimaschutzprogramm, Beschluss der Bundesregierung vom 13. Juli 2005 (Sechster Bericht der Interministeriellen Arbeitsgruppe „CO_2-Reduktion"); online: http://www. klimastrategie.de/download/bund_klimaschtzprog2005.pdf (accessed 7 March 2011)

IPCC (Intergovernmental Panel on Climate Change) (2007): Climate change: Impacts, adaptation and vulnerability, in: M. Parry et al. (eds.), Contribution of Working Group II to the Forth Assessment Report, Cambridge, UK: Cambridge University Press

– (2007a): Annex I Glossary, in: Climate change 2007: The physical science basis, in: S. Solomon et al. (eds.), Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, UK, New York, NY: Cambridge University Press

– (2007b): Appendix I: Glossary, in: Climate change 2007: Impacts, adaptation and vulnerability, in: M. Parry et al. (eds.), Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, UK: Cambridge University Press, 7–22

Kassam A. / M. Smith (2001): FAO methodologies on crop water use and crop water productivity, Expert meeting on crop water productivity, Rome 3–5 December 2001, Paper CWP-M07; online: http://www.fao.org/landandwater/aglw/cropwater/docs/method.pdf (accessed 7 March 2011)

Kemper, K. / A. Dinar / W. Blomquist (eds.) (2005): Institutional and policy analysis of river basin management decentralization, The principle of managing water resources at the lowest appropriate level – when and why does it (not) work in practice?, Washington, DC: World Bank

Kingston, C. / G. Caballero (2009): Comparing theories of institutional change, in: *Journal of Institutional Economics* 5 (2), 151–180

Knight, J. (1992): Institutions and social conflict, Cambridge: Cambridge University Press

Landgraf, L. (2001): Chancen für den Landeswasserhaushalt Brandenburgs, in: B. Weigert / C. Steinberg (eds.), Nachhaltige Entwicklung in der Wasserwirtschaft: Konzepte, Planung und Entscheidungsfindung, Berlin: IFV Wasserforschung e.V., 205–224

Llamas, R. et al. (2007): Legal aspects of groundwater ownership in Spain, in: *Water International*, 32 (4), 676–684

Lopez-Geta, J. et al. (2008): Current state of groundwater use in Spain, Paper presented at the International Geological Congress 6–14 August 2008, Oslo, Norway

McCabe, T. (1990): Turkana pastoralism: A case against the tragedy of the commons, in: *Human Ecology* 18 (1), 81–102

Meister, H.-P. et al. (2009): Floating houses and mosquito nets: Emerging climate change adaptation strategies around the world, IFOK Study, Boston: Meister Consultants Group, Inc.

Meyer, S. (1996): Ökonomische Theorie der Umweltpolitik: Der Erklärungswert der Neuen Politischen Ökonomie für umweltpolitische Entscheidungsprozesse (Economic theory of environmental policy: Value added of new political economics for decision-making for environmental policies), Bergisch Gladbach, Köln: Josef Eul

Ministerio de Medio Ambiente (2006): PNACC: Plan nacional de adaptación al cambio climatico, Marco para la coordinacion entre administraciones publicas para las actividades de evaluacion de impactos, Vulnerabilidad y adaptacion al cambio climatico;online: http://www.presidencia.gub.uy/_web/cambio_climatico/Plan_Nal_Espana.pdf (accessed 10 Dec. 2009)

– (2007): Plan especial de actuacion en situaciones de alerta y eventual sequia en la cuenca hidrografica del Ebro; online: http://oph.chebro.es/DOCUMENTACION/Sequia/PES.pdf (accessed 25 Feb. 2010)

MLUR (Ministerium für Landwirtschaft, Umweltschutz und Raumordnung) (2001): Brandenburgs Wasser wird knapp, in: *Brandenburger Agrar- und Umweltjournal* 7/8, 36–37

Molle, F. / P. Mollinga / R. Meinzen-Dick (2008): Water, politics and development: Introducing water alternatives, in: *Water Alternatives* 1 (1), 1–6

Monsees, J. / M. Grossmann (2004): Institutionelle Arrangements zur Wasserregulierung: Staubeiräte in Brandenburg, in: I. Dombrowsky / H. Wittmer / F. Rauschmayer (eds.), Institutionen in Naturschutz und Ressourcenmanagement – Beiträge der Neuen Institutionenökonomik, UFZ-Bericht 07/2004, Leipzig: Umwelt Forschungszentrum Leipzig-Halle (UFZ), 99–109

Monsees, J. (2004): The German water and soil associations – self-governance for small and medium scale water and land resources management, in: *Journal of Applied Irrigation Science* 39 (1), 5–22

– (2008): Governancestrukturen für Fließgewässer: Eine vergleichende Institutionenanalyse gewässerunterhaltender Verbände und Behörden, Baden-Baden: Nomos

Moss, T. (2003): Das Flußgebiet als Handlungsraum: Institutionenwandel durch die EU-Wasserrahmenrichtlinie aus raumwissenschaftlichen Perspektiven, Münster: LIT Verlag

Neubert, S. et al. (eds.): Integriertes Wasserressourcenmanagement (IWRM), Ein Konzept in die Praxis überführen, Bonn: Nomos

North, D. (1991): Institutions, in: *Journal of Economic Perspectives* 5 (1), 97–112

Nunes Correia, F. / A. Kraemer (1997): Dimensionen Europäischer Wasserpolitik, Eurowater 2, Themenberichte Band 2, Berlin: Springer

OECD (Organisation for Economic Co-operation and Development) (2000): Environmental indicators for agriculture: Methods and results, Executive summary 48, Paris: OECD; online: http://www.oecd.org/dataoecd/0/9/1916629.pdf (accessed 7 Mar. 2011)

Ostrom, E. (1986): An agenda for studying institutions, in: *Public Choice* 48, 3–35

– (1998): The institutional analysis and development approach, in: E. Loehman / M. Kilgour (eds.), Designing institutions for environmental and resource management, Cheltenham: Edward Elgar, 68–90

– (2005): Understanding institutional diversity, Princeton, Oxford: Princeton University Press

Ostrom, E. / L. Schroeder / S. Wynne (1993): Institutional incentives and sustainable development: Infrastructure policies in perspective, Boulder, Colo.: Westview Press

Paavola, J. / N. Adger (2006): Fair adaptation to climate change, in: *Ecological Economics* 56 (4), 594–609

Projektgruppe Landschaftswasserhaushalt (2003): Landschaftswasserhaushalt in Brandenburg, Kurzfassung zum Sachstandsbericht mit Konzeption, Potsdam: Ministerium für Landwirtschaft, Umweltschutz und Raumordnung

RMCWATER.com (2009): San Diego integrated regional water management plan; online: http://www.rmcwater.com/clients/sdirwmp/home.html (accessed 6 Dec. 2009)

Ribeiro, M. et al. (2009): Design of guidelines for the elaboration of regional climate change adaptation strategies, Study for European Commission – DG Environment – Tender DG ENV. G.1/ETU/2008/0093r, Vienna: Ecologic Institute

Saleth, M. / A. Dinar (2004): The institutional economics of water, A cross-country analysis of institutions and performance, Cheltenham: Edward Elgar Publishing

Sadoff, C. / M. Muller (2009): Water management, water security and climate change adaptation: early impacts and essential responses, Global Water Partnership TEC Background Papers 14

Scheumann, W. (2005): IWRM ohne Dränage?, Der Fall Kesterson Kalifornien und seine Folgen. in: S. Neubert et al. (eds.): Integriertes Wasserressourcenmanagement (IWRM), Ein Konzept in die Praxis überführen, Bonn: Nomos, 115–134

Schlager, E. (2007): Community management of ground water, in: M. Giordano / K. Villholth (eds.), The agricultural ground water revolution: opportunities and threats to development, Wallingford, Oxon, UK: CABI, 131–152

Schleyer, C. (forthcoming 2011): Institutioneller Wandel von Meliorationssystemen: Eine vergleichende Studie in Ostdeutschland und Polen, Aachen: Shaker

Schöfer, J. (2008): Stabilisierung des Landschaftswasserhaushalts in Brandenburg – Projektbilanz nach 5 Jahren Maßnahmenförderung, H2O, Infoblatt für die Mitglieder des DWA Landesverbandes Nord-Ost 13, 3

Shah, T. (2008): Taming the anarchy: Groundwater governance in South Asia, Washington, DC: Resources for the Future Press

Smith, J. (1997): Setting priorities for adapting to climate change, in: *Global Environmental Change* 7 (3), 251–264

Sperling, F. / F. Szekely (2005): Disaster risk management in a changing climate, Informal discussion paper prepared for the World Conference on Disaster Reduction on behalf of the Vulnerability and Adaptation Resource Group (VARG), Washington, DC

Swart, R. et al. (2009): Europe adapts to climate change: Comparing national adaptation strategies, PEER Report 1, Helsinki: Partnership for European Environmental Research (PEER)

The Economist (2010): The Appalachia of the West – California's agricultural heartland threatens to become a wasteland, Economist Print Edition, 21 Jan. 2010

Theesfeld, I. (2010): Institutional challenges for national ground water governance: Policies and issues, in: *Ground Water* 48 (1), 131–142

Theesfeld, I. / C. Schleyer / O. Aznar (2010): The procedure for institutional compatibility assessment: Ex-ante policy assessment from an institutional perspective, in: *Journal of Institutional Economics* 6 (3), 377–399

UNESCO (United Nations Educational, Scientific and Cultural Organization) (2005): The precautionary principle: World commission on the ethics of scientific knowledge and technology, Paris: UNESCO

UNFCCC (United Nations Framework Convention on Climate Change) (1992): United Nations Framework Convention on Climate Change; online: http://unfccc.int/essential_background/convention/background/items/2853.php (accessed 5 Dec. 2009)

– (2009): Least developed countries portal; online: http://unfccc.int/cooperation _support/least_ developed_ countries_portal/items/4751.php (accessed 10 Dec. 2009)

Upper Kings Basin Integrated Regional Water Management Authority (2009): News Release, 11 September 2009; online: http://www.krcd.org/_pdf/News_Release_Water_Authority.pdf (accessed 9 Dec. 2009)

Vatn, A. (2005): Institutions and the environment, 1st ed., Northampton, USA: Edward Elgar

Verheyen, R. (2002): Adaptation to the impacts of anthropogenic climate change – the international legal framework, in: *Review of European community and international environmental law (RECIEL)* 11 (2), 129–143

Walker, B. et al. (2004): Resilience, adaptability and transformability in social–ecological systems, in: *Ecology and Society* 9 (2), 5; online: http://www.ecologyandsociety.org/vol9/iss2/art5/ (accessed 7 March 2011)

*Water Education Foundation (*2009): online: http://www.water-ed.org/watersources/community.asp?rid=6 &cid=564 (accessed 7 Dec. 2009)

Wechsung, F. et al. (eds.) (2008): Die Ertragsfähigkeit ostdeutscher Ackerflächen unter Klimawandel, PIK Report 112, Potsdam: Potsdam-Institut für Klimafolgenforschung

WRIME, Inc. (2007): Upper Kings River Basin Integrated Regional Water Management Plan (IWRMP), Prepared for the Upper Kings Basin Water Forum and Kings River Conservation District; online: http://project.wrime.com/krcd/krcd_pdf.htm (accessed 9 Dec. 2009)

Yin, R. (1994): Case study research: Design and methods, 2nd ed., Thousand Oaks, Calif.: Sage

Young, O. (2002): The institutional dimensions of environmental change: fit, interplay, and scale, Cambridge, MA: MIT Press

Publications of the German Development Institute

Nomos Verlagsgesellschaft

Messner, Dirk / Imme Scholz (eds.): Zukunftsfragen der Entwicklungspolitik, 410 p., Nomos, Baden-Baden 2004, ISBN 3-8329-1005-0

Neubert, Susanne / Waltina Scheumann / Annette van Edig, / Walter Huppert (eds.): Integriertes Wasserressourcen-Management (IWRM): Ein Konzept in die Praxis überführen, 314 p., Nomos, Baden-Baden 2004, ISBN 3-8329-1111-1

Brandt, Hartmut / Uwe Otzen: Armutsorientierte landwirtschaftliche und ländliche Entwicklung, 342 p., Nomos, Baden-Baden 2004, ISBN 3-8329-0555-3

Liebig, Klaus: Internationale Regulierung geistiger Eigentumsrechte und Wissenserwerb in Entwicklungsländern: Eine ökonomische Analyse, 233 p., Nomos, Baden-Baden 2007, ISBN 978-3-8329-2379-2 (Entwicklungstheorie und Entwicklungspolitik 1)

Schlumberger, Oliver: Autoritarismus in der arabischen Welt: Ursachen, Trends und internationale Demokratieförderung, 225 p., Nomos, Baden-Baden 2008, ISBN 978-3-8329-3114-8 (Entwicklungstheorie und Entwicklungspolitik 2)

Qualmann, Regine: South Africa's Reintegration into World and Regional Markets: Trade Liberalization and Emerging Patterns of Specialization in the Post-Apartheid Era, 206 p., Nomos, Baden-Baden 2008, ISBN 978-3-8329-2995-4 (Entwicklungstheorie und Entwicklungspolitik 3)

Loewe, Markus: Soziale Sicherung, informeller Sektor und das Potenzial von Kleinstversicherungen, 221 p., Nomos, Baden-Baden 2009, ISBN 978-3-8329-4017-1 (Entwicklungstheorie und Entwicklungspolitik 4)

Loewe, Markus: Soziale Sicherung in den arabischen Ländern: Determinanten, Defizite und Strategien für den informellen Sektor, 286 p., Nomos, Baden-Baden 2010, ISBN 978-3-8329-5586-1 (Entwicklungstheorie und Entwicklungspolitik 7)

Faust, Jörg / Susanne Neubert (Hrsg.): Wirksamere Entwicklungspolitik: Befunde, Reformen, Instrumente, 432 p., Nomos, Baden-Baden 2010, ISBN 978-3-8329-5587-8 (Entwicklungstheorie und Entwicklungspolitik 8)

[Books may be ordered only through publishing house or bookshops.]

Book Series with Routledge

Brandt, Hartmut / Uwe Otzen: Poverty Orientated Agricultural and Rural Development, 342 p., Routledge, London 2007, ISBN 978-0-415-36853-7 (Studies in Development and Society 12)

Krause, Matthias: The Political Economy of Water and Sanitation, 282 p., Routledge, London 2009, ISBN 978-0-415-99489-7 (Studies in Development and Society 20)

[Books may be ordered only through publishing house or bookshops.]

Springer-Verlag

Scheumann, Waltina / Susanne Neubert / Martin Kipping (eds.): Water Politics and Development Cooperation: Local Power Plays and Global Governance, 416 p., Berlin 2008, ISBN 978-3-540-76706-0

Studies

57 *Neubert, Susanne et al.:* Agricultural Development in a Changing Climate in Zambia: Increasing resilience to climate change and economic shocks in crop production, 244 p., Bonn 2011, ISBN 978-3-88985-493-3

56 *Grimm, Sven et al.:* Coordinating China and DAC Development Partners: Challenges to the aid architecture in Rwanda, 200 p., Bonn 2010, ISBN 978-3-88985-492-6

55 *Weinlich, Silke:* Die Reform der Entwicklungszusammenarbeit der Vereinten Nationen: Eine Analyse des Verhaltens und der Positionierung wichtiger Staaten gegenüber Reformoptionen, 121 p., Bonn 2010, ISBN 978-3-88985-491-9

54 *Ifejika Speranza, Chinwe:* Resilient Adaptation to Climate Change in African Agriculture, 311 p., Bonn 2010, ISBN 978-3-88985-489-6

53 *Krause, Matthias et al.:* Formalisation and Business Development in Mozambique: How important are regulations? 131 p., Bonn 2010, ISBN 978-3-88985-490-2

52 *Voionmaa, Petra / Michael Brüntrup:* German Aid for Trade: Past experience, lessons learnt, and the way forward, 150 p., Bonn 2009, ISBN 978-3-88985-488-9

51 *Wiemann, Jürgen et al.:* Laos on its Way to WTO Membership: Challenges and opportunities for developing high-value agricultural exports, 186 p., Bonn 2009, ISBN 978-3-88985-487-2

50 *Makhan, Davina:* Linking EU Trade and Development Policies: Lessons form the ACP-EU trade negotiations on Economic Partnership Agreements, 184 p., Bonn 2009, ISBN 978-3-88985-486-5

[Price: 10,00 Euro; books may be ordered directly from the DIE or through bookshops.]

Discussion Paper

5/2011 *Ifejika Speranza, Chinwe:* Promoting Gender Equqality in responses to Climate Change: The case of Kenya, 52 p., Bonn 2011, ISBN 978-3-88985-534-3

4/2011 *Altenburg, Tilman*: Industrial Policy in Developing Countries: Overview and lessons from seven country cases, 97 p., Bonn 2011, ISBN 978-3-88985-533-6

3/2011 *Hensengerth, Oliver:* Interaction of Chinese Institutions with Host Governments in Dam Construction: The Bui dam in Ghana, 47 p., Bonn 2011, ISBN 978-3-88985-532-9

2/2011 *Dafe, Florence:* The Potential of Pro-Market Activism as a Tool for Making Finance Work in Africa, 45 p., Bonn 2011, ISBN 978-3-88985-531-2

1/2011 *Erdle, Steffen:* Industrial Policy in Tunisia, 63 p., Bonn 2011, ISBN 978-3-88985-529-9

20/2010 *Haldenwang, Christian von / Maksym Ivanyna:* Assessing the Tax Performance of Developing Countries, 42 p., Bonn 2010, ISBN 978-3-88985-528-2

19/2010 *Bučar, Maja:* Science and Technology for Development: Coherence of the common EU R&D policy with development policy objectives, 48 pl, Bonn 2010, ISBN 978-3-88985-527-5

18/2010 *Ondřej Horký:* The Europeanisation of Development Policy: Acceptance, accommodation and resistance of the Czech Republic, 31 p., Bonn 2010, ISBN 978-3-88985-526-8

[Price: 6,00 Euro; books may be ordered directly from the DIE or through bookshops.]

A complete list of publications available from DIE can be found at:
http://www.die-gdi.de