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The *Climate Learning Ladder.* A Pragmatic Procedure to Support Climate Adaptation

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ABSTRACT
We introduce a new pragmatic procedure called the 'climate learning ladder' to structure policy analysis, support reflection and identify critical decisions to support climate adaptation. This tool is the result of the reflexive learning process that occurred while developing innovative appraisal methods in the Alxa League of Inner Mongolia, China, and in the Guadiana river basin in the European Union. Building capacities to cope with climate change requires going beyond simply providing 'more knowledge' on climate impacts to policy makers. Instead, climate adaptation can be understood as a multi-step social process in which individuals and organizations need to learn how to (1) manage different framings of the issues at stake while raising awareness of climate risks and opportunities, (2) understand different motives for, and generate adequate incentives or sanctions to ensure, action, (3) develop feasible options and resources for individual and collective transformation and collaboration and (4) institutionalize new rights, responsibilities and feedback learning processes for climate adaptation in the long term.

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Introduction

IN THIS PAPER WE USE A SOCIAL LEARNING PERSPECTIVE TO INTRODUCE A PRAGMATIC 'TOOL' FOR IDENTIFYING critical decisions to support climate adaptation. We call this new procedure 'the climate learning ladder' (CLL). Its development is the result of our self-reflection and learning while developing innovative appraisal methods in two very different social–ecological contexts of the world: the Alxa League in Inner Mongolia, China, and

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the Guadiana river basin in the European Union. Our research was part of the EU project ADAM (*Adaptation and Mitigation Strategies*; www.adamproject.eu), which explored the requirements for innovatively appraising climate adaptation and mitigation options. The CLL can be used to support self-reflection from a multi-scale perspective among researchers and policy makers by exploring how individual aspects of climate adaptation, such as personal perceptions, motives and options, can be linked to collective dynamics needed for adaptation such as the transformation of organizations and institutions. The intention of the CLL is not to provide specific policy advice, but rather to encourage identification of, and critical reflection on, the various individual and collective factors that need to be considered in integrated climate adaptation efforts.

Social learning occurs when agents are successful in developing new collective capacities to deal with common problems and are able to implement conscious and long term adaptive changes in cognitive frameworks of action, and in institutional arrangements, so as to achieve common goals that would otherwise not be achieved individually. Social learning allows agents to pursue new pathways of action based on collective experiences, ethical awareness or ideals. The very idea that a society *can learn* is embedded in the realistic assumption that societies do not simply change from one state to another, but that the social and ecological conditions in which their development is based can be *improved* according to the specific structure of knowledge and human values. From a radical, social–constructivist perspective, societies cannot learn, they can only change. Yet we can find examples of social learning in the institutionalization of welfare policies, in normative processes supporting equal work opportunities and in numerous political movements for upholding basic human rights and freedoms. In contrast, social unlearning can also occur when social rights, freedoms and capacities to deal with common problems and goals are lost. Social unlearning can be particularly noticeable in situations of acute conflict and war, where the building or maintenance of open organizations and institutions based on the integration of plurality and diversity, a main source of learning and reframing, may be impeded.

Within the EU project HARMONICOP (*Harmonising Collaborative Learning*, www.harmonicop.info), social learning was understood as the process by which agents develop new social capabilities to deal with common problems by (1) reflecting on the institutional and biophysical *contexts* in which they carry out their activities, (2) developing structured *processes* of collaboration and engagement capable of managing new contents and relatively open participation boundaries and (3) producing a series of *outcomes* that affect and transform the original contexts in the desired direction. The success of a social learning process depends on the extent to which new institutions are capable of changing the original contexts in which agents originally operated in a fully encompassing and long lasting way (Pahl-Wostl *et al.*, 2008; Tàbara, 2005, Tàbara *et al.*, 2009). Therefore, social learning entails not only the gaining of new technical skills to do the same (single loop, or simple learning) but reframing the way in which the issues at stake are perceived – including social interactions with other agents – through the transformation of the governing assumptions and values of the system of reference (also referred to as second/third loop or reflexive, learning). The concept of sustainability learning (Tàbara and Pahl-Wostl, 2007) tries to go one step further in this conceptualization by underlining the need to develop new patterns of social–ecological system interactions that reverse the current trends of global resource misuse and unsustainability.

The use of the social learning perspective to understand climate adaptation is based on the assumption that successful adaptation cannot simply be achieved by developing technical skills, but also implies the development of new patterns of interaction between different agents and organizations and also between social–ecological systems. We understand that capacity building in the domain of climate change adaptation requires a certain degree of institutional transformation and/or the creation of new institutions. Successful adaptation also requires new forms of awareness and the development of structured procedures capable of reframing and transforming the original contexts in which the most vulnerable populations operate. New tools and methods can be devised to help build new institutions and capacities that reduce social vulnerabilities and take advantage of the new opportunities created by the new climate situation. In this respect, the normative principles summarized by Brown *et al.* (2005, p. 263) on social learning for environmental management can be applied to foresee how new climate adaptation appraisal processes may be devised. In the view of Brown *et al.* (2005), such procedures should be reflexive, systemic, participatory, negotiated, include ideas across social boundaries, integrate conflict, respect diversity and promote transformation and accountability.

In this paper, we do not intend to develop an in-depth review of the different theoretical perspectives dealing with social learning related to environmental, sustainability and climate issues (see Armitage *et al.*, 2008; Blackmore

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et al., 2007; Keen *et al.*, 2005; Pahl-Wostl *et al.*, 2008; Pelling *et al.*, 2008; Schusler *et al.*, 2003; Siebenhüner, 2006) or adaptation at different scales (see Adger *et al.*, 2005a, 2005b, 2007). Our purpose is instead a pragmatic one aimed at providing a simple operational tool that can be used by interdisciplinary research teams, policy analysts and practitioners to support reflexive learning on climate adaptation (for an alternative diagnostic framework with practical implications see Steyaert and Jiggins, 2007). This tool is premised on a 'bottom-up' procedure based on three basic assumptions: first, that not everything can be learnt at the same time, such that the acquisition and application of knowledge to deal with complex issues can be enhanced if such learning processes are structured and integrated as a series of steps; second, that different learning processes are needed to support learning for different social–ecological contexts and problems; third, that it is impossible to develop all of the collective skills needed to deal with complex issues such as global environmental change at one time, hence many different skills and capacities must be acquired along the way.

In the following sections we begin by introducing the case sites and the methods used. We then describe the content and purpose of the climate learning ladder (CLL). Finally, we present and discuss some of the results and lessons learned from its development and application.

Contexts and Research Methods

Our research focused in two very distinct social and political contexts of the world that at the same time face similar challenges regarding climate adaptation. Our first research case explored institutional and local populations' strategies to cope with increasing desertification in the semi-desert region of Inner Mongolia, China, in the administrative unit of Alxa League, while our second case examined the potential impacts of, and responses to, climate change in local communities in an arid region of the Guadiana River in Iberia, with a special focus on the lower part of the basin. In both cases, quantitative and qualitative data on political arrangements, potential climate impacts on local economic activities, and strategies for adaptation and mitigation to climate change were collected and compared (see Tàbara *et al.*, 2009; Werners *et al.*, 2010). The researchers adhered to a common set of research methods, which were mainly qualitative, including questionnaires and stakeholder meetings. At the same time, methodological differences arose due to the various researchers' academic backgrounds, expectations and scientific practices. While such differences proved inevitable, and were at times frustrating, they provided the inspiration for devising an appraisal method that could integrate different types of knowledge and results. The diversity of researchers' backgrounds and practices thereby constituted a unique platform for mutual learning, which resulted in the development of the 'climate learning ladder'.

Inner Mongolia is China's northern border autonomous region and covers an area of 1.18 million sq km, or 12.3% of the country's territory. Our case study area, the Alxa League, is the westernmost administrative unit of Inner Mongolia and it is characterized by a semi-arid to arid environment formed by steppe, deserts, oasis and mountains. The eastern edge of the Alxa Plateau is bordered by the Helan Mountain and the Yellow River. Cereal crops and vegetable farming are practiced, but are generally only possible with irrigation. As a result of ongoing degradation of the soil and grassland cover, Alxa League is also a key area of origin of sandstorms, which have reportedly become more frequent and intense over the last decades. The findings reported here draw on satellite monitoring of land use and biophysical conditions in Alxa, three sets of questionnaires and qualitative fieldwork carried out with local populations affected by land degradation (ADAM, 2009). The report by Neufeldt and Jia (2009) provides both quantitative and qualitative results obtained from 98 questionnaires (containing 43 questions each) from 23 settlements in Alxa, while the work by West (2009) provides further qualitative findings from 38 respondents (obtained via interviews, and group discussions with ecological migrants in two regions and key informants and focus group discussions with local policy-makers and practitioners) on the issue of ecological migration. Two stakeholder workshops were also held, in May 2007 and in May 2009 respectively, involving over 50 participants in addition to researchers. Our analysis focused on two large policy programmes that have been carried out in this area: first, the fencing off of grazing areas and the government assisted relocation of people living in some designated degraded steppes and deserts, and, second, the restoration of two of the main regional water sources, the Heihe River and the Juyan Lake. The first measures under these large-scale projects were implemented in 2000 and have continued until now.

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The Guadiana is one of the three main transboundary river basins between Spain and Portugal, and covers a total area of 66 800 sq km. It is characterized by an arid environment with a low annual precipitation of about 440 mm/year. Regionalized IPPC-SRES A1 climate change scenarios show a possible rise in temperature of 4–7 degrees at the end of the century and a possible drop in rainfall of up to 60 per cent (Moreno, 2005). Our research concentrated on the lower Guadiana sub-region and involved the wide variety of actors, options and strategies for adaptation that can be observed in a relatively small biophysical context of less than 10 000 sq km. The Lower Guadiana encompasses four differentiated social–ecological areas, whose geographic boundaries are distinguished both by national administrative borders and by the biophysical conditions of inland versus coastal environments. With local variations, inland areas generally consist of a 'Dehesa' landscape, which is defined by extensive oak-based multifunctional land use, while near the coast intensive agriculture, industry and tourism developments predominate. Climate change may affect these areas differently, for example with potentially more forest fires inland versus exposure to sea level rise on the coast. Fieldwork in the Guadiana river basin included two stakeholder workshops that were conducted in December 2006 in the town of Mértola in Portugal, and in February 2009 in the city of Seville, Spain. In addition, a number of in-depth interviews with local and regional stakeholders were carried out. In total, 45 people were consulted, with respondents ranging from farmers, water authority delegates, regional policy makers and industry to NGOs (ADAM, 2009).

The CLL is the result of the actual reflexive learning process that occurred within this project and the two case studies described above. It represents an unintended outcome of research and a useful analytical tool that helped retrospectively to make sense of the work carried out within the ADAM project and that also has relevance for policy making. A main methodological insight gained from the comparative research presented here refutes the idea that providing more scientific knowledge to policy makers about climate impacts is enough to guarantee adaptation to climate change.

The 'Climate Learning Ladder'

As a result of our research experiences in our case studies we understood that climate adaptation is best conceived as a process of social learning in which agents and organizations need, above all, to reflect upon four dimensions.

1. *Perceptions, frames and awareness*. Managing different ways of framing given situations and action priorities, while at the same time being able to raise awareness about the new climate risks, vulnerabilities and opportunities.
2. *Incentives, sanctions and motives*. Developing an effective set of tailored incentives, by taking into account different interests, motives and systems of preference.
3. *Individual adaptation options and resources*. Producing a realistic portfolio of feasible options and resources for collaboration and individual transformation.
4. *Institutions and feedback processes*. Securing long-term feedback learning processes through institutions capable of redistributing new rights and responsibilities in an efficient, equitable and ecologically robust way as new knowledge, experiences and values emerge.

We structured these four dimensions as a kind of a hypothetical 'ladder' in a chain of conditions that we feel are crucial for adaptive climate capacity building. The four steps represent a series of different research questions and policy arenas that need to be considered in order to reflect on how to successfully develop such climate learning capacities in the long term. 'Unlearning', or 'moving down the climate ladder', may also occur wherever agents and institutions lose the knowledge and capacities acquired over time to cope with climate risks. Figure 1 summarizes this argument by providing a series of simple questions that climate analysts and decision-makers may pose while examining and devising climate adaptation strategies from this social learning, multi-step, perspective.

More specifically, each step is related to the following types of question and decision arena.

1. *Perceptions, frames and awareness*. The first condition for making any strategy aimed at dealing with a given issue is to perceive the need or opportunity for doing so. Thus, the first questions to be asked here are whether agents perceive the need to adapt to climate change, and what the opportunities and constraints are to improve climate adaptation awareness. Policy analysts and practitioners interested in exploring and/or improving

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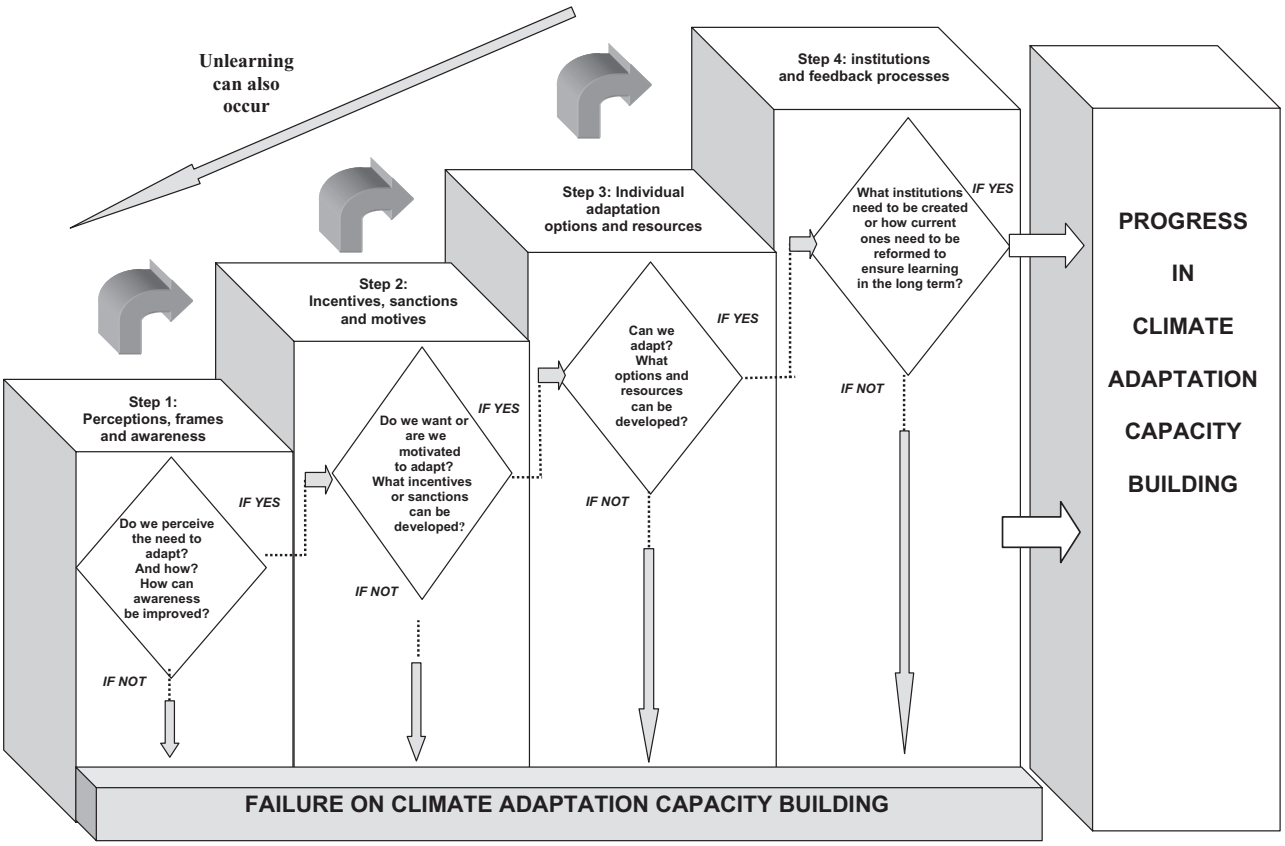

Figure 1. The climate learning ladder

awareness of climate change risks and opportunities may need to ask how different agents frame the issues at stake, whether different perceptions can be reconciled or improved on the basis of new scientific insights, or to what extent different sources of knowledge, experience and judgment play a role in constructing climate change as a social and political issue (Nilson and Biel, 2008; Leiserowitz, 2006). Failure to reconcile such perceptions may impede action. An excessive social relativist position may be instrumentally used by those who want to stop action and may therefore be detrimental to social learning. The understanding of vulnerabilities and the downscaling of scientific knowledge and assessments to the regional or local level may not merely be a question of providing facts and figures to local and regional authorities. Rather, the challenge is to integrate the different organizational languages, views and expectations of the responsible institutions and agents involved, regarding climate adaptation.

2. *Incentives, sanctions and motives.* People may be aware of particular problems but lack sufficient motivation to deal with them. Understanding the multiple motives that drive different agents is crucial to articulate collective action. Thus in this step we ask whether agents are sufficiently motivated to adapt to climate change, and what types of incentive or sanction can be developed to support effective action. Different incentives will have different effects on efficiency, equity and power relationships. Marcun Olson (1971) argued that collective action is only possible when selective incentives are devised so as to make it rational for individual actors to act. Whenever the costs of inaction are greater than those of acting, or the expected private benefits of contributing to the public good are greater than its costs, individuals will participate in the provision of the public good. However, action regarding climate change may also be motivated by altruistic or moral concerns. The governance of climate change is therefore a question of how to manage different motives, expectations and moral norms (Nilsson and Biel, 2008) as well as diverse situated power relationships. Although sanctioning

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is often regarded as necessary for inducing action, as pointed out by the common pool resources literature, the efficiency of sanctioning can be limited. This is especially the case in situations of rapid environmental change where the resource governance institutions in charge of developing these sanctions may not have sufficient time to be developed (as is the case for the management of global marine resources; see Berkes *et al.*, 2006; Dietz *et al.*, 2003; Ostrom, 2000; Ostrom *et al.*, 1994).[1] Specifically, in using the ladder to reflect on the work carried out within the case studies, we posed questions regarding what specific incentives were or could be implemented in the selected regions to encourage adaptation, and how different actors might react to different sets of incentives.

3. *Individual adaptation options and resources.* As a third step in the process of climate capacity building, analysts and policy makers can benefit from thinking through how to provide feasible options and resources to individuals and organizations to adapt to climate change. Questions arise here as to whether individual climate adaptation options are possible, what forms of individual transformations can be developed, what new technologies may be implemented and what new networks can be promoted. Specifically, and to become effective and meaningful, climate options need to be mainstreamed into broader strategies of sustainable development and seen by individuals to be opportunities to improve their own personal conditions in many other areas (Tàbara, 2009; Weaver *et al.*, 2006). Among other questions, we asked what types of resource had been or could be mobilized to support climate adaptation, for what purposes and by whom.
4. *Institutions and feedback processes.* The only way to secure sustained collective action is to develop new institutional arrangements or modify the existing ones in ways that clarify different rights and responsibilities of both individuals and organizations (Young *et al.*, 2008). In some cases such institutional changes may require modification in the existing regimes of property rights (Connor and Dovers, 2004). Thus, as a final step in the process of using the ladder as a heuristic tool for research and policy reflection, one needs to ask what the current state of development of climate adaptation institutions is, what new institutional arrangements can be created or how the existing ones can be modified so as to ensure learning feedbacks and adaptation in the long term. In this respect, and following North (1993), institutional change may be affected by interactions, competition or complementarities with other institutions, including the types of knowledge used by these institutions, and the mental constructs of the members who develop these institutions.

While we have depicted this reflexive learning process about what is needed for climate capacity building as a sequence of conditions related to particular questions and decisions, it is obvious that, once institutions are created, they may also contribute positively to the whole process of climate learning or, negatively, unlearning. Institutions may actively contribute to, or impede, awareness, develop or prevent the implementation of new incentives or sanctions, and create new options and resources or divert them to other purposes. Indeed, learning occurs as a result of iterative, rather than linear, processes. This is why, from this social learning perspective, agents working in institutions involved in climate adaptation need to find ways of reflexively reframing and redefining their original goals as new information, knowledge, experiences and value judgments emerge from different sources. In other words, institutions need to 'learn how to change to adapt and learn how to adapt to change'.

Results and Discussion

In this section we apply the CLL to reflect on the process of developing adaptive capacity in Alxa League and the Guadiana river basin. The CLL was only developed during the last stage of the three-year ADAM project, and therefore it could only be tested in the last workshops of the two case studies. In the Guadiana case, the CLL was also explored as a deliberative tool to guide discussions during the last workshop. Prior to the workshop, the ladder was given to regional policy makers, who acknowledged its usefulness to structure and to communicate the measures included in their regional climate adaptation programme. In the Alxa League, the key questions

[1] While we agree that the contributions of this literature are immense, we also believe that it also presents some difficulties to provide simple but robust operational guidance for practitioners and policy makers about 'what to do' when confronted with such a difficult challenge as building capacities to cope with climate change – which is the focus of this paper. In this regard, Agrawal (2003, p. 243) points out that 'scholars of commons have discovered far more variables that potentially affect resource management than is possible to analyze carefully'.

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of the ladder were translated and given to the participants in the final workshop. Here it proved to be more difficult than in the Guadiana to gain full insights into the ladder's application due to difficulties in communication between participants and researchers. Hence further applications need to be made to explore and improve the CLL social–ecological robustness across different backgrounds and scales.

Perceptions, Frames and Awareness

In the Alxa League, researchers registered a growing awareness of the environmental degradation as reported not only by the resident populations but also by policy makers working in different levels of government. In the early 1990s, recurrent sandstorms reaching as far as Beijing prompted officials to develop decisive policies to halt the expansion of the desert and to try to reverse the degradation of the northwestern steppes. Policies such as enclosing and protecting the steppes and Helan mountainous forests and meadows, large-scale tree plantations, aerial seeding and water management efforts in the Heihe River and Juyan lake have been implemented. Results from our stakeholder meetings and questionnaires show that most residents (for example 74 per cent of the first questionnaire, $N = 49$) believed that the quantity of water resources has substantially decreased during the last decades in Alxa. Desertification, reduced grassland productivity and climate variability are being perceived as limiting local agricultural activities and livestock rearing. These perceptions are also representative of the actual state of the environment. More than 90% of the grassland in Alxa has suffered from degradation and the productivity of grassland has been reduced by 25.3% in the last 20 years. Policies oriented to restore regional ecosystems in Alxa League, as in other places in China, have mostly been framed in terms of poverty reduction and improving the living conditions of local populations. Therefore, it is difficult to clearly distinguish between the two goals of climate adaptation and economic development (Wang and Fang, 2007). Indeed, in this context, promoting economic growth is generally seen as one of the best strategies to deal with environmental degradation, political integration and enhanced welfare for rural populations (see Harris, 2004).

In the Guadiana basin, concerns about the worsening quality of the river ecosystem have increased in the last decade. In this case, scientific research played an important role in raising awareness of the potential climate impacts in the Guadiana. Many EU projects have been carried out in this river basin during the last decade. The new awareness about the degradation of the Guadiana river basin led in 2007 to the formation of a coalition of environmental groups including WWF, Birdlife International and others prompting the Spanish government to remove the Tablas de Daimiel National Park from the UNESCO Biosphere Reserves list if no urgent actions were taken. Illegal groundwater extraction is widespread and pressures on the river basin resources are mounting from agriculture, industry and new urban developments. The conservation of biodiversity, which is increasingly being perceived as an important tourist asset, is also threatened by the growing competition for water resources. The new Alqueva Dam in Portugal is particularly representative of the conflicting viewpoints in this river basin. On the one hand environmental groups see it as one final blow to the ecological quality of the river basin, while on the other hand many Portuguese farmers and developers see it as a unique opportunity to improve standards of living.

Incentives, Sanctions and Motives

In the Alxa League, many of the large scale, government sponsored ecological restoration projects are motivated by fears that ecological degradation threatens regional development. Interesting developments in Alxa include the development of economic incentives to support local water conservation, and payments to farmers and herders for retiring sloped agricultural land, planting trees and shrubs on degraded grasslands or relocating to new or existing settlements. In both cases, economic incentives for protecting the natural environment have played a key role in establishing the legitimacy and success of the policies. However, as pointed by out by Zhang (2009, p. 14) some of these incentive schemes have produced perverse effects. People participating in these projects are increasingly more concerned about the compensation schemes than in actual restoration goals: 'Pursuing "project economy" has gradually detached ecological projects from solving ecological problems'. Moreover, research in other regions and interviews with beneficiaries in Alxa suggests that some people may reconsider their conservation activities or choose to move back to their homelands if the compensation programs end in the absence of sufficient income opportunities or subsidies (for example Runhong, 2001; West, 2009).

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In the case of the Guadiana, new EU regulations such as the European Water Framework and also the EC regional development funds INTERREG increasingly support new types of interregional collaboration that are important for climate adaptation. Progress towards adaptation is mostly achieved by a greater rationalization of the use of water resources and through initiatives that help the diversification and strengthening of local economies. However, as was stated by the participants who attended the last Guadiana workshop, the large-scale illegal extraction of groundwater means that developing robust strategies to deal with growing water scarcity and climate change would require going beyond voluntary or local financial incentives. It was made clear that such voluntary incentives ought to be complemented with a strong system of sanctions, which should be implemented from a multi-level governance system, for example including from national and European levels.

Individual Options and Resources

Fieldwork conducted in Alxa found that there was very little awareness among ecological migrants about what individuals or communities could do themselves to adapt to climate change, government support notwithstanding (West, 2009). The dominant approaches to deal with increasing ecosystem degradation in Alxa have been to develop policies to resettle local populations, fence large former pasture areas or implement large-scale water redistribution policies to restore aquatic ecosystems, often with little consultation of local people. Such policies have not been exempt from criticism due to the high social costs, although some authors argue that there are indications of ecological improvement in some regions (for different interpretations see Dickinson and Weber, 2007; Williams, 1996, 2002; Li *et al.*, 2007; Rogers and Wang, 2006, Yonghuan and Shengyne, 2006). Nonetheless, due to government interventions, by the end of 2008 the Heihe water reallocation efforts had restored the water flow to the Juyan Lake – which had previously almost disappeared due to overexploitation in the river's upper reaches. Water tables in the Ejina River basin have also risen, vegetation cover has increased and the dust and sand that were previously exposed on the dry lake bottom and riverbeds have been reduced. It has been claimed that that people tend to adapt more to governmental policies than to climate change as such (Zhang, 2009). Options for transforming individual practices are much conditioned by existing political programmes and agendas, which tend to be implemented in a top-down fashion, rather than supporting individuals and communities to develop bottom-up strategies and options to cope with environmental change.

In the Guadiana river basin, several forms of autonomous adaptation (not directly led by explicit government policies) have been observed. These include modifications in the distribution of time spent in economic activities, intensification and diversification of farming, as well as embracing other non-farming activities such as rural tourism. For instance, in the extensive olive groves inland, farmers have created co-operatives, which are able to increase their economies of scale, guarantee quality certifications and augment their chances to obtain a better price for their products. However, in some cases, such strategies have been carried out at the cost of reducing some of the traditional and less productive varieties of olives, thus reducing the local agricultural biodiversity and making such production in the long term potentially more vulnerable to climate and biophysical change. Furthermore, while national and regional climate adaptation plans are now underway in both Portugal and Spain, these plans are still framed in terms of representing biophysical impacts, and do not assess feasible options for agent and institutional transformations. An exception to this general mode of framing adaptation is the Andalusian government, which provides one of the most advanced cases of regional climate adaptation planning in Spain.

Institutions and Feedback Processes

In the Alxa League, we observed that adaptation has indeed occurred as a result of strong policy measures and political will, but we fear that such adaptation may be limited in the long term by a lack of local engagement and significant institutional innovation at different levels of governance, evidenced by a lack of individual or household adaptive capacities among the local populations. The difficulties of enforcing the partial grazing ban and of monitoring protected areas are evidence of this challenge, and highlight the relative precariousness of these policies, which depend greatly on continued subsidies and economic compensation. Furthermore, the difficulty

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encountered by scientists and stakeholders in arriving at a common understanding of possible arrangements or avenues for coping with climate change – although some of these are now being progressively overcome – limits the possibilities to innovate and to develop diverse forms of adaptation in different sectors and communities. In particular, the Alxa case study illustrates the importance, as well as the limitations, of a strong government structure that is capable of undertaking and implementing large-scale technologically and market-oriented adaptation actions but with limited room for individual initiatives, creativity and responsibilities for pursuing alternative options for adaptive action or alternative development pathways.

The Guadiana river basin case illustrates the possibilities for regional, cross-border collaboration, as well as the role of particular 'policy entrepreneurs' in integrating knowledge and policy instruments from a trans-boundary perspective (Cots *et al.*, 2009; McEvoy *et al.*, 2008). At the same time, it also highlighted the limits of a large number of EU research projects focussing on biophysical trends and climate impacts that are not really integrated with policy decision making. In our view, such projects very rarely affect the existing institutional arrangements or result in the redistribution of rights and responsibilities. The reality that such research initiatives are carried out in a context of relatively weak national governance structures may also impede the development of significant capacities for climate adaptation in the long term.

A key insight from this comparative research was that learning to adapt to climate change is not only a question of producing 'more' scientific knowledge. Building climate adaptation capacities requires going beyond the dominant paradigm of expert appraisal, tool development and communication. To produce efficient, equitable and long lasting results, diverse, efficient and context-based integrative science-policy interfaces need to be developed. Feedback learning processes need to be institutionalized to transform perceptions, motives and incentives, and to generate options for action as new knowledge and judgements emerge.

The climate learning ladder provides a rapid appraisal procedure, which can assist the identification of critical decisions that individuals and organizations need to consider when designing climate learning capacities. Each step of the CLL embodies its own set of reflexive questions and decision arenas. Our results indicate that the CLL tool can be useful to structure empirical research, and facilitates deliberation and analysis. In this regard it can be considered as an integrated assessment tool for supporting climate capacity building and helping to reflect on complex issues regarding climate change adaptation among different stakeholders.

The use of the CLL in the Alxa League and the Guadiana river basin shows that in both cases local populations and governmental authorities have for some time been aware of the potential impacts of climate change in their regions (Step 1). However, such impacts cannot be separated from historical and present resource management practices. The growing awareness of the negative effects of global warming, and in particular the growing role played by climate science and international policy, seem to have created the conditions for developing new incentives for action in this domain (Step 2). In the case of the Guadiana, EU cooperation programmes (such as INTERREG) or the implementation of the Water Framework Directive supported the development of collaborative actions and of new 'policy entrepreneurs' that can promote climate adaptation. In the Chinese case, economic compensation is provided to people affected by environmental degradation to assist with their relocation to other areas, albeit with varying choice to refuse these policies. It is interesting to note that new economic incentives are also beginning to be developed to improve efficiency in water use in Inner Mongolia even though the dominant policy discourse is still framed in terms of sanctions. Regarding individual options for transformation and collaboration (Step 3), in the Chinese context, these are very much dictated by governmental agents. However, given the rapid modernization and urbanization with a more market oriented economy, a more complex social structure is emerging. While resettlement policies have been criticized for their impact on the articulation of social networks and minority ethnic groups, they are also acknowledged for employment, bringing new well-being opportunities to rural people who were living under very difficult conditions. In this regard, the scale and speed of individual transformations has been much greater in the Chinese case than in the European one. In the Guadiana case, local populations have continued more or less carrying out the same types of occupation, despite having diversified their income somewhat through, for example, the introduction of tourist activities. Finally, and concerning the development of new institutions (Step 4), both cases illustrate important pitfalls as well as potentialities.

In short, the CLL is a 'process result'. It is the outcome, largely unexpected, of a reflexive learning process within an ambitious project. The ladder used empirically was able to identify two key practical insights from the research concerning adaptation capacity building: (i) the need to allow for and to encourage a diversity of learning processes

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to support climate change adaptation and (ii) the need to build a coherent framework in which social and institutional data and insights can be collected and analysed in a structured way, and from a variety of political contexts. The CLL is an operational heuristic tool that we believe may be useful for other researchers and practitioners to support their learning processes and interactions with other agents in a time in which new tools and procedures for climate adaptation are urgently needed.

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