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Changing Climate in Protected Areas?

Risk Perception of Climate Change by Biosphere Reserve Managers

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Protected areas can exemplify progress in climate change mitigation and adaptation. What role do protected area managers – and their risk perception and response – play in this context? A global survey with biosphere reserve managers yields some surprising results.

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Abstract

Since protected areas (PAs) comprise about twelve percent of the world's surface, PA managers are in a key position regarding in situ biodiversity conservation against the background of emerging climate change. PAs can exemplify progress in climate change mitigation and adaptation. What role do PA managers – and their risk perception and response – play in this context? A global survey with biosphere reserve (BR) managers investigated this issue using a combined quantitative and qualitative approach. Results suggest that climate change risk perception is largely linked to economic power: in non-high-income countries climate change was perceived as being significantly less relevant than in high-income countries. In non-high-income countries, other threats such as illegal activities are regarded as being much more important than climate change impacts. Thus, socio-political factors and the connection between management and science seem to play an important role in risk perception of BR managers. In situ biodiversity conservation efforts with regard to climate change mitigation and adaptation must inform BR managers about likely climate change impacts, involve them in transdisciplinary research activities, and speed up necessary mitigation and adaptation measures.

Keywords

biosphere reserves, climate change, protected areas, risk perception

The Role of Protected Area Managers in Biodiversity Conservation

Climate change is an increasingly relevant threat imposing direct and indirect pressure on protected areas and their management (Araújo et al. 2004, Coulston and Riitters 2005, Hannah et al. 2007). Although considerable research has focused on climate change mitigation and adaptation, the problem is generally limited to a "technical" one. Comparably little work has been conducted on the "social" aspects of the problem and on the perception of climate change by protected area (PA) managers who manage almost twelve percent of the world's surface (WDPA 2007). The protection, restoration, or establishment of genetically diverse populations and species-rich ecosystems in PAs allow for continuous carbon storage as well as for increasing the climate change adaptation potential of species. Adaptation options further include the reduction of already existing threats (many of which are further exacerbated by climate change) and the connection of PAs into networks, allowing plant and animal species to migrate and shift distribution (SCBD 2003). In addition, diverse ecosystems may constitute important adaptation measures in anticipation of increased pressures or demands on ecosystem goods and services, or to compensate for likely biodiversity losses (SCBD 2003, Hulme 2005). This requires the collaboration across PA boundaries, with communities and land users. PA managers, however, are struggling with a variety of challenges and threats besides climate change – inter alia management deficiencies, illegal activities (Mehring and Stoll-Kleemann 2008, in this issue), and ex-

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ternal stressors such as pollution and invasive species (Cowling 1999, Carey et al. 2000, MEA 2005 a). They often have to allocate management resources according to which risk is perceived to be the most pressing one. Thus, the risk perception of PA managers plays a central role when facilitating appropriate action, successful communication with stakeholders, and effective decision-making for climate change mitigation and adaptation. This is of particular relevance to international processes such as the efforts of the *Convention on Biological Diversity (CBD)* to establish a fully functioning global network of PAs for in situ biodiversity conservation (SCBD 2003). Another example is the intention of the *UNESCO Man and Biosphere (MAB) Programme* to use the World Network of Biosphere Reserves (WNBR) as learning sites for climate change mitigation and adaptation strategies and practices. However, it was only at the *3rd World Biosphere Reserve Congress,* in February 2008 in Madrid, that the issue of climate change received major attention. It is now included in the *Madrid Action Plan* as one of the three most pressing global challenges for the programme (UNESCO MAB 2008). This development raises hope that the urgency of the issue will be "vertically" communicated to national and local levels. It could then contribute to the initiation of climate change mitigation and adaptation projects in biosphere reserves.

PA managers are key actors when addressing climate change impacts with corresponding management strategies for climate change mitigation, such as:

- afforestation and reforestation, contributing to both carbon-uptake and forest biodiversity conservation,
- restoration of degraded ecosystems, or
- land management for sustainable forestry and agriculture in buffer areas and transition zones contributing to enhanced carbon uptake,

as well as for management strategies for climate change adaptation that

- reduce other threats to biodiversity (pollution, invasive alien species, etc.),
- promote corridors linking fragmented landscapes to improve dispersal capabilities of plant and animal populations, and
- extend small PAs to increase resilience (SCBD 2003).

With reference to the abovementioned, the following two main questions guide this study:

1. Is climate change perceived as a major threat to the achievement of conservation targets by PA managers?
2. What are the factors influencing their risk perception?

We aim to answer these questions by hypothesising that climate change risk perception is not only higher in places where vulnerable ecosystems exist, but also influenced by the occurrence of other threats and pressures – because impacts, other than those of climate change, may alter the biodiversity status much quicker and thus shape the risk perception of BR managers. To clarify the terminology of the present study, we define the terms risk, danger, and threat in the following box.

BOX: Risk, Danger, and Threat – A Terminology

- "Risk" is defined here as the potential harm or injury that may arise from some current process or from some future event (here: climate change) (see also Renn 2008).
- "Danger" is defined here as the possibility of a threat implying harm or injury. In contrast to "threat", danger is of a hypothetical, frequently non-targeted nature, with its subject (here: possible climate change) and object (here: any component of our biotic and abiotic environment) not being obviously manifest.
- "Threat" is used here in the sense of an indication of imminent or manifest danger that implies the identification of the obvious subject or source (here: changing temperature or precipitation, for example) and the object (here: a specific component of biological diversity) against which its impact is directed.

In general, the notions of "risk" and "danger" as well as of "danger" and "threat" seem to be fairly overlapping, both are frequently used with one and the same meaning. Thus we suggest that each risk can turn into danger with increasing probability of occurrence, and "each fundamental danger can be viewed as potential threat in that it can become, subject to certain conditions, a tangible threat" (Gatsko 2006), and is capable of inflicting real harm or injury (here: on components of biological diversity) (see also Pohl and Geipel 2002).

We focus on biosphere reserves, as the concept of the *MAB Programme* aims at integrating global biodiversity conservation and human resource use (see Stoll-Kleemann and Welp 2008, in this issue), and, with its zoning concept, offers the necessary spatial flexibility to facilitate adaptive management and to foster landscape connectivity.

Methodology

In order to assess the climate change risk perception of BR managers, we studied possible factors affecting individual risk perception. We further searched for comparable case studies to calibrate our approach and to verify our results. As we argue that the vulnerability of ecosystems might play a major role in climate change risk perception of BR managers, we have also researched a classification of ecosystems according to their vulnerability to climate change impacts. Thus, the methodology of this paper stands on two pillars:

1. an in-depth literature review of:
   - concepts of risk perception of climate change,
   - empirical findings from research on climate change risk perception,
   - vulnerability of PAs' ecosystems[1] to climate change.
2. quantitative and qualitative data from the *GoBi (Governance of Biodiversity)* project[2]:

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1 Although we only focus on BRs in this study, we assessed the literature on ecosystem vulnerability in protected areas in general.

2 *www.biodiversitygovernance.de*

- Quantitative data from a global survey among BR managers in the second half of 2006.[3] We evaluated answers to the following three questions:
  - Please order the following four threats (climate change, illegal activities, invasive alien species, pollution, R. S. et al.) according to their severity within your BR. 1 represents the biggest threat, 4 the smallest threat.
  - What are the two biggest threats to biodiversity within your BR?
  - What is the relevance of (...) (climate change, R. S. et al.) to the success of biosphere reserve management? Make a cross anywhere between 10 for "very high" to 0 for "not at all".
- Qualitative data from an interview with BR managers in South Africa was consulted for a better understanding of the argument. The *GoBi* research group conducted 13 in-depth case studies, mostly in tropical countries, which complement the quantitative data from surveys and questionnaires.

Theories of Risk Perception

In almost four decades of research, the science of risk perception has yielded a broad variety of theories and a lively debate on the factors determining risk judgement. Two major schools have shaped the discourse in risk perception theory: the so-called Psychometric Paradigm and the Cultural Theory.

Paul Slovic is the central figure in a group of researchers who have proposed a survey-based method for studying risk perception, the Psychometric Paradigm. In his more recent work, Slovic identified a set of mainly psychological aspects that influence risk perception: emotion, worldview, and trust are factors that help a layman navigate through a world full of threats. Further decisive factors "point toward the role of power, status, alienation, trust, perceived government responsiveness, and other socio-political factors in determining perception and acceptance of risk" (Slovic 1999, p. 693). In particular, the role of socio-political factors seems to be of relevance when discussing the results of our surveys later on.

The Cultural Theory of risk perception (Douglas and Wildavsky 1982) refers to the observation that different cultures fear different sorts of threats, and that solidarity, as well as externally imposed order, play an important role in individual risk perception (Muzquiz et al. 1999). Differences in social structure lead to different attitudes towards the world, which in turn lead to a specific cultural bias in risk perception.

In recent years, this dichotomy of theoretical schools is losing ground in favour of a more complex and heterogeneous perspective on risk perception (Thompson and Rayner 1998, Renn 2005). For example, Dessai et al. (2004) concentrate on the concept of danger proposing to distinguish between external definitions of danger for example by experts and internal definitions of danger dependent on individual experience and perception. Both must be taken into account when designing policy responses to climate change impact. On the one hand, perceptions of what constitutes danger are inter alia informed by a technical analysis of risk. On the other hand, perceptions of what constitutes dangerous climate change will have an impact on the formulation of research questions and the political environment steering public research funds for the assessment of rapid climate change (Dessai et al. 2004). Thus, comprehensive knowledge of PA managers concerning climate change, as well as their involvement in respective research activities, is crucial for any operational response to dangerous climate change.

Empirical Findings From Recent Studies on Climate Change Risk Perception

While, to date, research on climate change risk perception in the PA context remains scarce, we provide a summary of case studies on climate change risk perception in general, in order to expand on the theoretical aspects introduced in the preceding chapter. This is of particular interest with respect to the discrepancies between risk perception and possible reactions (i. e., adaptation and mitigation measures).

Over the last few years, a growing number of empirical studies researched climate change risk perception among different social groups primarily within industrialised countries (e. g., Stoll-Kleemann et al. 2001, Leiserowitz 2003, Palutikof et al. 2004, Lorenzoni and Pidgeon 2006, Lorenzoni et al. 2007). Stoll-Kleemann et al. (2001, p. 107) revealed psychological denial mechanisms of randomly selected individuals when confronted with the need for action to mitigate climate change. Their findings suggested "that more attention needs to be given to the social and psychological motivations (...) (of governing, R. S. et al.)", and led her to the question, "why individuals erect barriers (...) (against, R. S. et al.) their personal commitment to climate change mitigation."

In general, the above cited case studies assessing the public's risk perception can be summarised with these statements:

- Climate change is perceived as a serious danger by most of the citizens.
- The general public's understanding of the underlying causes of global warming is weak.
- People do not feel the necessity to change their lifestyles to address the problem.

Hence, in our study we focused on the individual motivations of biosphere reserve managers, and on the conditions that determine these motivations.

3 Managers of 213 BRs participated in the survey. Almost half of the respondents are from national parks as legally constituted core areas of biosphere reserves. In many cases, the national park administration represents the managing bodies of the BRs. Thus, when we use the term "BR manager" in our study, we often in fact mean "PA managers".

Lowe and Lorenzoni (2007) in particular investigated expert perceptions for the management of climate change. The authors demonstrated that it is not feasible to define danger in relation to climate change solely by means of "external" risk analyses and assessments of system characteristics. To inform risk management, expert risk perception is rather supplemented by "internal" value judgements. Thus, expert risk conceptualisation regarding complex and uncertain issues such as climate change is based on both disciplinary knowledge and individual belief systems. This inevitably impacts on the shaping of solutions to the problem and points to aspects such as equity and fairness in international climate change negotiations (Lowe and Lorenzoni 2007).

The empirical studies mentioned above only concern developed countries. This fact supports the findings of Lowe and Lorenzoni (2007), who point out that the climate change discourse has mainly been framed by experts and the public from these countries.

There are only few examples for case studies on climate change risk perception from developing countries. One example is Adelekan and Gbadegesin (2005) for Nigeria. Their assessment of public perception among inhabitants of the city of Ibadan revealed a superficial understanding of the implications of climate change – which was ascribed to religious and superstitious reasons by one third of the respondents.

To summarise, risk perception among laymen and experts is influenced by individual belief systems and psychological mechanisms that may hamper a timely reaction to facilitating climate change adaptation and mitigation.

Vulnerability of Ecosystems and Protected Areas to Climate Change

With our first hypothesis we argue that climate change risk perception is higher in places where vulnerable ecosystems exist. This includes the assumption that climate change impacts should be more strongly recognisable in environments that are particularly susceptible to these impacts. Some PAs are considerably more threatened by the immediate consequences of climate change: mountain ecosystems, coastal and marine, as well as polar ecosystems (IPCC 2007, SBSTTA 2007). Various degrees of short and long-term threats to the particular geographies need to be considered.

Climate change is considered to be both a direct and indirect threat to biodiversity. It exacerbates conventional threats by altering ecosystems, shifting species range, or increasing the frequency of extreme weather events such as droughts and floods (Barber et al. 2004). In many cases, it imperceptibly impairs resilience of ecosystems through a series of additional, gradually increasing or occasional stressors. We want to explain why this is a particular challenge for PAs and for risk perception of PA managers.

In recent years, a number of studies have focused on ecosystems and species vulnerability to climate change. Hannah et al. (2007) suggest that PAs can be an important conservation strategy in a moderate climate change scenario. However, "limiting climate change is an essential complement to adding protected areas for conservation of biodiversity" (Hannah et al. 2007, p. 131). Being spatially static and increasingly isolated by habitat transformation, PAs are only poorly suited to the dynamics of climate change impacts (Hannah et al. 2007). The combination of climate change and other global change drivers (e. g., invasive alien species, pollution) may exceed the ability of species and ecosystems to naturally adapt to climate change impacts. Three main obstacles that determine species' potential to adapt can be found in the literature (Walther et al. 2002, Parmesan and Yohe 2003, Araújo et al. 2004, Parmesan 2006):

1. The species' genetic potential does not allow either a shift in distribution range or the ability to adapt as quickly as climatic conditions are changing.
2. Natural and anthropogenic barriers, such as mountains, watercourses, and highly fragmented natural habitats, may hinder a species' distribution shift although the genetic potential exists.
3. The change of essential species' compositions and interactions, due to, for example, a highly competitive invasive alien species or altered predator-prey interactions may impede successful adaptation.

According to these findings, climate change strongly affects individual species' performance, species compositions, and thus the entire system's vulnerability to climate change. This applies especially to climate change impacts acting in combination with other threats, in particular habitat destruction (IPCC 2007, Root and Schneider 2006, Thomas et al. 2004).

Assessing Climate Change Risk Perception of Biosphere Reserve Managers

Overall Risk Perception of Climate Change

In a global survey on BR management, the *GoBi* research group asked the respondents to rank a set of four given threats according to the severity within "their" BR, with 1 representing highest severity and 4 the lowest. The four categories were climate change, illegal activities (summarising e. g., poaching, illegal logging), invasive alien species, and pollution. We selected these threats according to the main direct drivers of change in biodiversity and >

TABLE 1: Risk perception for four given threats from all participating biosphere reserve experts (n = 213).

threats	valid replies	arithmetic means	normalised value	rank
illegal activities	199	2.221	1.000	**1**
climate change	193	2.534	0.824	**2**
invasive alien species	197	2.538	0.822	**3**
pollution	198	2.636	0.767	**4**

ecosystems as defined by the *Millennium Ecosystem Assessment* (MEA 2005b), and by aggregating threats from a standard classification developed by the Conservation Measures Partnership (IUCN and Conservation Measures Partnership 2006). Although all four given threats are main direct drivers of change on a global level (WWF 2004, MEA 2005b, Leverington et al. 2008), they may not represent the most pressing threats to each individual BR. Table 1 presents the results from the ranking as described.

Out of the four given threats, climate change is perceived as the second most important threat to biodiversity in BRs. Illegal activities, however, clearly dominate the ranking while the remaining threats show a very similar arithmetic mean making it difficult to detect a ranking order of significance (see table 1).

Risk Perception of Climate Change as a Function of Ecosystem Vulnerability

According to our first hypothesis, data from BRs covering ecosystem types with higher vulnerability to climate change should show high awareness of climate change as a threat.

We compared the results from table 1 with the vulnerability of ecosystems in BRs. The resulting table 2 shows that climate change risk perception is ranked second in BRs without vulnerable ecosystems (normalisation value 0.894) and third in the set of BRs with vulnerable ecosystems (normalisation value 0.738). This means that climate change seems to be of lower relevance in BRs with vulnerable ecosystems. This result runs contrary to our hypothesis that climate change risk perception is higher in places where vulnerable ecosystems exist.

Risk Perception of Climate Change in Comparison with Other Threats to Biodiversity

As depicted in table 1, illegal activities occupy the leading position on the list of main threats to biodiversity in BRs, thus presenting a much larger problem than any other given threat (see also Mehring and Stoll-Kleemann 2008, in this issue). We will come back to this result in more detail in the following chapter.

Part of the complexity of the climate change phenomenon is the difficulty to ascribe its impacts to the ultimate cause since uncovering cause-effect chains often requires rather advanced analytical long-term efforts. Thus, the results from table 1 suggest that more obvious cause-effect chains dominate BR managers' risk perception, which is also exemplified by statements from open expert interviews, for example from a South African case study: "There is quite a lot of (climate, R. S. et al.) modelling going on. While you are watching this, you had better watched the current (rural and urban, R. S. et al.) development, it's transforming the landscape at the same time. (...) (It, R. S. et al.) is going much faster than global warming is."

TABLE 2: Risk perception for four given threats as a function of vulnerability of biosphere reserve ecosystems (n = 213).

vulnerable	threats	valid replies	arithmetic means	normalised value	rank
yes	illegal activities	154	2.130	1.000	1
	pollution	154	2.532	0.785	2
	climate change	150	2.620	0.738	3
	invasive alien species	152	2.691	0.700	4
no	invasive alien species	45	2.022	1.000	1
	climate change	43	2.233	0.894	2
	illegal activities	45	2.533	0.742	3
	pollution	44	3.000	0.506	4

Many illegal activities show such obvious cause-effect chains. Illegal activities in PAs, however, do not play equal roles (and biodiversity is not evenly distributed) around the globe. This is illustrated by an assessment showing that high-income countries generate about 80 percent of the global economic output while accommodating less than 20 percent of global biodiversity and less than 25 percent surface area of all PAs (SCBD 2008).

The unequal global distribution of PAs, biodiversity, and economic power has thus triggered a new hypothesis: the ranking of climate change as a threat may differ according to a country's economic power. We use the gross national income per capita (GNI/cap) as defined by the World Bank (2007) as an indicator not only for the level of dependency on natural resources. As high-income countries in general also have a high Human Development Index (HDI), the GNI/cap is also considered to be a fairly approximate indicator for the level of environmental awareness and education contributing to the adaptive capacity of a society in the face of a changing environment. 18 out of the leading 20 world economies (World Bank 2007) are also heading UNDP's *Human Development Report* country ranking according to their HDI (UNDP 2006). According to the Environmental Sustainability Index (ESI), richer countries tend to score high in "social and institutional capacity for environmental sustainability" in comparison with poorer countries that are challenged by "funding investments in environmental protection" and "creating functioning institutions" (Esty et al. 2006).

Risk Perception of Climate Change in Relation to Gross National Income Per Capita

By distinguishing between high and non-high-income countries (according to GNI/cap), our data suggests a connection between GNI/cap and climate change risk perception. By distinguishing between high and non-high-income countries (according to GNI/cap), our data suggested a connection between GNI/cap and climate change risk perception. But when we evaluated the answers to the question "What is the relevance of climate change to the success of biosphere reserve management?" according to GNI/cap, our data revealed no significant difference in the perception of climate change risks of BR managers in high-income countries and in non-high-income-countries. The answers with regard to climate change tend to show a higher variance than most of the other factors assessed.

A difference, according to GNI/cap, could be detected when analysing the answers to the question "What are the two biggest threats to biodiversity in your biosphere reserve?" Here, the fraction of BR managers quoting "climate change" is eight times

higher in high-income countries (24) than in non-high-income countries (3). The difference is more than 13 times as large when computing percentages for each of the two sub-groups: 27 percent for high-income countries (answers from 89 BRs) and two percent for non-high-income countries (answers from 123 BRs).

Table 3 indicates that BR managers in high-income countries perceived climate change together with pollution and invasive alien species as a more important threat than illegal activities. In contrast, BR experts from non-high-income countries consider climate change, together with pollution and invasive alien species, as least important. In fact, the positioning of climate change and illegal activities is contrary in high- and non-high-income countries. This leads to the conclusion that climate change is a relevant risk from the point of view of all BR managers in the sample. Illegal activities in non-high-income countries, however, stand out in the ranking and seem to be of higher relevance than any other threat.

Regional Differences in Risk Perception of Climate Change: The European Case

We found significant regional differences in risk perception, for example between East and West Europe: The variance in evaluations from West European biosphere reserve managers is lower than in the answers from East Europe, while the relevance of climate change for the success of biosphere reserve management is judged higher in West Europe. We will come back to this particular result in the discussion.

Discussion

We detected a notable consistency of climate change risk perception among BR managers from high-income countries and argue – with reference to our comparison between West and East Europe – that this also applies to politically and culturally broadly homogenous regions.

One of the less researched external definitions of risk perception is the socio-political dimension. While we initially assumed that it is mainly the marked difference in GNI/cap that triggers climate change risk perception, particular regional differences have led us to consider socio-political undercurrents as an additional driving force. With reference to Cultural Theory, a particular socio-political framework results in a characteristic construction of democracy and nature (Thompson 2003). The difference in climate change risk perception between West and East European BR managers underlines Slovic's (1999) assumption that socio-political factors such as *trust and perceived government responsiveness* may play a pivotal role in risk perception. In Central and Eastern Europe, societies are affected by profound transformations that are inter alia accompanied by

- a traditional distrust in the reliability of public institutions (OECD 2000),
- low political commitment from decision-makers,
- weak cooperation with the non-governmental sector, and
- a lack of active participation and public awareness in environmental affairs (CEEWEB 2003).

In short, the social construction of democracy or the socio-political background is quite different from West European countries with their longer democratic tradition.

Continuous societal (climate change) discourse goes along with a high degree of information diffusion and sufficient capacity for civil engagement. The level of awareness and the motivation to participate in discussions is steered by *information input and knowledge* (among other factors). In non-high-income countries, societal discourse is usually much less developed than in high-income countries. Moreover, the global climate change discourse is mainly framed by politicians, scientists, and media from developed countries (Lowe and Lorenzoni 2007). The majority of the high-profile research institutions investigating climate change impacts are located in high-income countries. The same applies to the increase in media coverage on the issue of climate change, especially since the publication of the latest *IPCC Report* (IPCC 2007, see also Egner 2007). Thus, climate change has become a widespread concern in high-income countries, presumably because sources of information are generally manifold, well developed and continuously updated. Staying updated about research results as well as the proposed action for adaptation and mitigation of climate change impacts might be challenging in an environment that provides only limited information resources. In the climate change case, our results support Slovic's (1987, p. 283) earlier suggestions that the level of knowledge influences risk perception: climate change is perceived as more dangerous a threat, the more knowledge and information is available. We base our assumption for these conditions in high-income countries – as compared with those in non-high-income countries – on the HDI as indicator.

The novelty and complexity of climate change goes hand-in-hand with *uncertainty* about the scope and character of likely impacts. Climate change impacts are repeatedly judged as too complex and too intermingled with other factors to be detected separately or to be clearly identified as direct effects of climate change. In public perception, climate change is generally linked to extreme weather or catastrophic weather events, which usually soon dis- >

TABLE 3: Risk perception of biosphere reserve managers for four given threats as a function of GNI/cap (n = 213), according to World Bank (2007).

GNI/cap	threats	valid replies	arithmetic means	normalised value	rank
high-income	climate change	83	2.169	1.000	1
	invasive alien species	84	2.262	0.949	2
	pollution	83	2.410	0.868	3
	illegal activities	82	3.110	0.486	4
non-high-income	illegal activities	117	1.598	1.000	1
	invasive alien species	113	2.743	0.523	2
	pollution	115	2.800	0.500	3
	climate change	110	2.809	0.496	4

appear from the public agenda (Lowe 2006). It is usually considered to be a moderate risk that is more likely to impact people and places far distant in space and time (Leiserowitz 2006). In contrast, threats such as poaching, fuel wood extraction, or illegal logging are much more evident to BR managers. They result from high pressure on natural resources due to widespread poverty (Wood et al. 2000, MEA 2005 a). We found clear evidence that BR management bodies in non-high-income countries are forced to focus their activities on the mitigation of illegal activities. Beyond this, studies have shown that BRs, in most cases, are seriously understaffed (WWF 2004, Leverington et al. 2008). Consequently, there might be only limited capacities left to deal with climate change risks. Hence, there appears to be considerable insecurity about what is related to climate change and what is just natural fluctuation in conditional changes.

From a political point a view, projected global climate change as assessed by the latest *IPCC Report* (IPCC 2007) will have severe *negative impacts on in situ nature conservation* and on the international efforts to establish an effective global network of PAs for the conservation of biodiversity. This is reflected in the *CBD* follow-up process where climate change is considered to be the new great threat to biodiversity requiring rapid action in developing tools for the implementation of biodiversity conservation activities that contribute to climate change adaptation (COP 8 CBD 2006). In the *Madrid Action Plan, UNESCO MAB* (2008) identified climate change as a major emerging challenge for the World Network of Biosphere Reserves (WNBR). BRs play a central role for rapidly seeking and testing solutions to the challenges of climate change. The *MAB Programme* is considered to add value through its integrated approach. The dynamic nature of climate change, however, requires solutions beyond conventional static in situ nature conservation approaches (Doyle and Ristow 2006) highlighting ecosystem connectivity and landscape permeability for migrating species and populations.

The results of our study are in line with other empirical work in high-income countries insofar as climate change is perceived as an emerging threat by most of the managers there. In high-income countries, it is even a "front-burner" problem in comparison to management issues such as illegal activities, invasive alien species, or pollution.[4]

Conclusions

This study exemplifies the significance of socio-political factors for the management of ecosystems in the light of climate change risk perception. It contributes to the theoretical foundations of risk perception science as it has found evidence for the significance of the socio-political dimension of expert risk perception. It further adds more insight to the possible causes for a lack of consideration for climate change impacts in ecological management discussed by Hulme (2005).

The following three major conclusions can be drawn from this study:

First, our study suggests a noticeable dependency of risk perception on macroeconomic conditions. Following the approach of Dessai et al. (2004, pp. 12 ff.), our study primarily considers external definitions of dangerous climate change such as physical vulnerability, additionally using economic resources, information, and education as indicators for "social vulnerability of individuals or groups to both existing climate variability and future climate change". It remains to be clarified what role other individual features, such as gender or professional background of BR managers, play in climate change risk perception.

Second, vulnerability of ecosystems only seems to play a minor role in the risk perception of BR managers. Ecosystems vulnerable to climate change impacts and represented in the BRs assessed are coral reefs or rainforests. The majority of vulnerable ecosystems are located in the tropics while most tropical countries are non-high-income countries. "According to the Third Assessment Report of the IPCC, developing countries are expected to suffer the most from the negative impacts of climate change. (...) In general, the vulnerability is highest for least developed countries in the tropical and subtropical areas" (AfDB et al. 2003, p. 5). Scarce management resources and significant pressure from illegal activities in these countries are two possible reasons for the low ranking of climate change compared to the other proposed threats. Hence, macroeconomic conditions affect risk perception of climate change indirectly.

Third, considering socio-political dimensions of risk perception in particular, trust and government responsiveness seem also to play a crucial role for BR managers. The lack of climate change research in developing and transformation countries adds urgency to capacity development needs, as in-country expertise would facilitate a more equitable involvement of these countries in the international discourse. The results of our study suggest that a capacity development initiative for PA managers in non-high-income countries with respect to global climate change and its likely impacts is an urgent matter.

Within the socio-political dimensions of risk perception we highlight the importance of the BR manager level on the ground. The BR managers provide a key role in the implementation of adaptation and mitigation strategies as well as in monitoring climate change impact. These strategies should also address individual features of BR managers. This might help bridging the still considerable implementation gap in biodiversity conservation, considering the manifold efforts at an international and national level and the persistent management deficiencies on the regional and local level. The multilateral environmental agreements in this policy area, such as the *UNESCO MAB Programme,* lack enforcement mechanisms at a sub-national level. Instead,

4 Due to our data basis, our study can only be an assessment of climate change risk perception, rather than an assessment of potential action.

they leave the implementation of their objectives under the sovereignty of the contracting nation states. The addressees of the most urgent measures for climate change mitigation and adaptation can thus be found at the national and sub-national levels. Efforts therefore need to be focused on the improved diffusion of strategies and plans into national institutions, and the vertical information flow from the decision-makers who developed *UNESCO MAB's Madrid Action Plan* down to the practitioners. Moreover, where sites are supposed to be model regions for adaptation to and mitigation of climate change impacts, their managers need to have the capacity to realise this. Not only in terms of knowledge and information, but also in terms of funds and staff. As long as other threats are overwhelmingly present and sites are understaffed and underfunded, there will not be space to address climate change. It is thus of equal importance that knowledge and information about existing mechanisms for fundraising and sustainable financial management reach the local practitioners.

Another major task is the enhanced involvement of PA managers within research activities to foster both their knowledge on likely climate change impacts, and transdisciplinary research efforts of the scientific community. PA managers must be put in the position to participate in the societal discourse about climate change adaptation and mitigation measures. They need social skills in order to apply participative management methods (Stoll-Kleemann and Welp 2008, in this issue). At best, PA managers can contribute their point of view and practical experience and participate when it comes to feasibility debates about potential mitigation and adaptation action. Against this background, the current efforts of the international community within the framework of the *CBD* follow-up process to raise sufficient funding for the world network of PAs gain particular relevance.

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