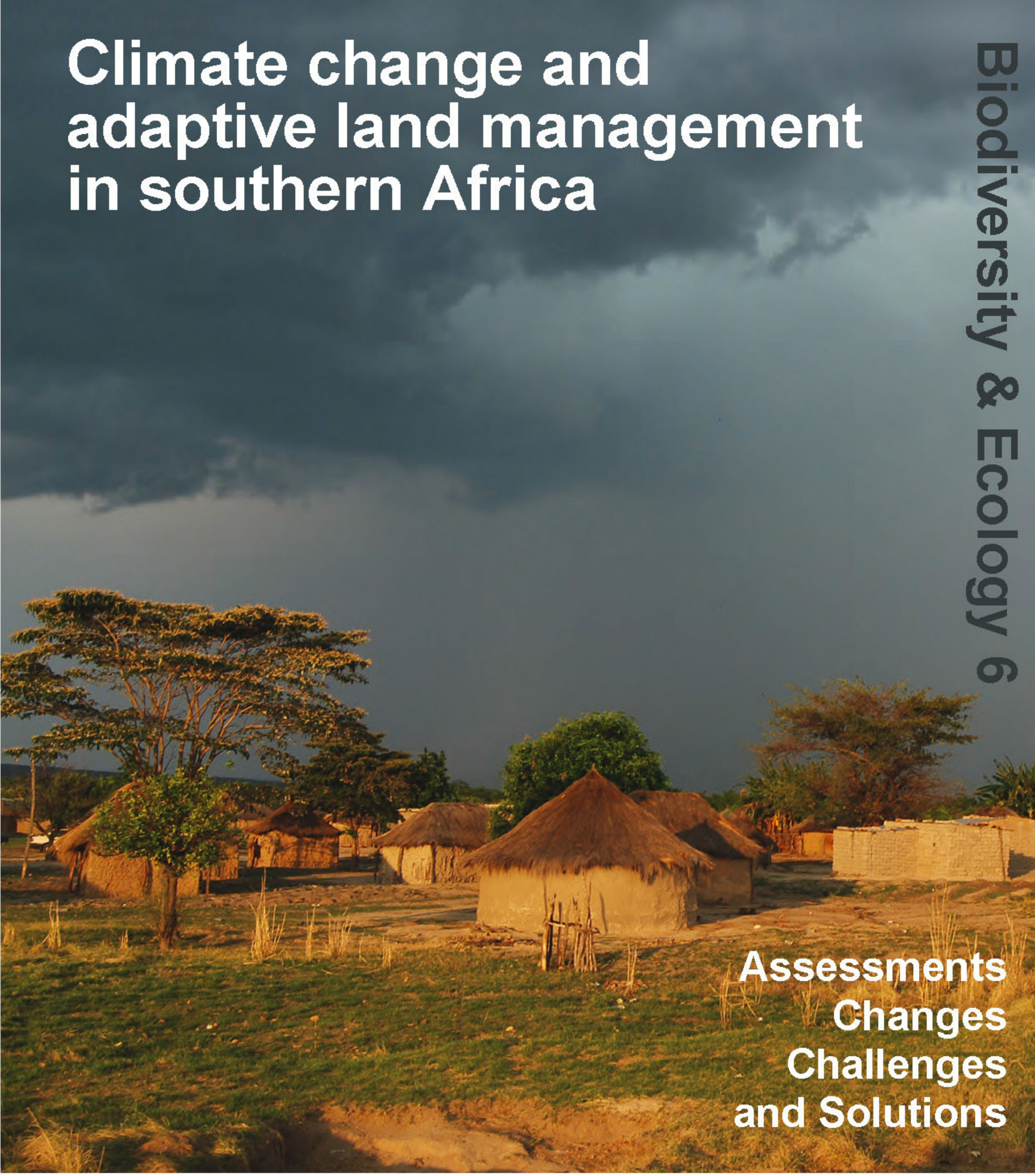
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



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Challenges
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Climate change and adaptive land management in southern Africa

Assessments, changes, challenges, and solutions

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Risk management

Risk management – a conceptual foundation

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Abstract: Risk is the potential interplay of a natural hazard, exposed elements in the respective area, and the vulnerability of these elements. We provide a general conceptualisation of risk against the background of globally increasing hazard events and, at the same time, increasing numbers of exposed and vulnerable elements resulting from population and economic growth as well as environmental degradation and exploitation of resources. We discuss general strategies for risk management and provide an overview of the situation in southern Africa, based on the field studies described in this chapter.

Resumo: Risco é a potencial interacção entre um perigo natural, elementos expostos na área respectiva e a vulnerabilidade desses elementos. A conceptualização geral de risco é dada em relação ao contexto do crescimento global de eventos de perigo e, ao mesmo tempo, ao aumento do número de elementos expostos e vulneráveis devido ao crescimento populacional e económico, bem como à degradação ambiental e exploração de recursos. Discutimos estratégias gerais para a gestão de riscos e fornecemos uma visão especial sobre a situação na África Austral, com base nos estudos de campo deste capítulo.

Introduction

In recent decades, the number of reported natural hazards such as earthquakes, tsunamis, storms, droughts, or floods has increased significantly. While most geophysical events (e.g. earthquakes), which are beyond the influence of humankind, remain generally constant with respect to intensity and occurrence over time, meteorological, hydrological, and climatological events pushed the annual total from about 200 in 1980 to almost 800 in 2016 (Munich Re, 2017). A prominent recent example is typhoon Haiyan hitting the Philippines, Vietnam, and China in 2013 and causing damage to 1.1 million houses and the evacuation and displacement of more than 4.5 million people. More than 6,200 people died in this disaster and the economic loss is estimated to have been US$ 10,500 M (Munich Re, 2014). At US$ 20,000 M, the economic loss caused by floods in China in 2016 was even greater. However, this was soon to be topped by the costliest tropical cyclone on record to date: Hurricane Harvey hitting the U.S. coast in 2017 and inflicting damage amounting to US$ 125,000 M. Due to heavy seasonal rains in this episode, rivers burst their banks and affected more than 60 million people (Munich Re, 2017). Further hydrological events, such as severe floods in India in 2015 and a recently occurring landslide in China in 2017, contribute to the increasing number of reported natural hazards. In the African context, particular attention is given to drought events, which affect vulnerable populations and frequently result in severe famines. Since 1900, 291 drought events have occurred on this continent with almost 850,000 people killed and up to US$ 3,000 M of economic damage (Masih et al., 2014). The most recent examples of droughts were aggravated by El Nino, leading to the humanitarian crisis in the Horn of Africa (FEWS-NET, 2017) and persisting water shortages in southern Africa (Archer et al., 2017).

In general, natural hazards such as floods, droughts, storms, and tropical cyclones, among many others, are potentially damaging physical events, phenomena, or human activities that are characterised by their location, intensity, frequency and probability (UN/ISDR, 2004).

However, natural hazards do not intrinsically cause harm to people, assets, and societies. Risks are only created when there is spatial and temporal coincidence of natural hazards in areas of exposed and vulnerable elements, such as individuals, households, communities, buildings, infrastructure, as well as agricultural commodities, and environmental assets. *Exposure* can generally be considered as the location and characteristics of the 'elements at risk'. *Vulnerability* is defined as "the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of a hazard" (UN/ISDR, 2004). The consequential *risks* and related potential disasters can be viewed as an interplay of complex reciprocity between potentially damaging physical events (in our case the focus is on water-related hazards such droughts and floods) and the vulnerability of the built and natural environment, society, and economy (Birkmann, 2006; Geiß & Taubenböck, 2013).

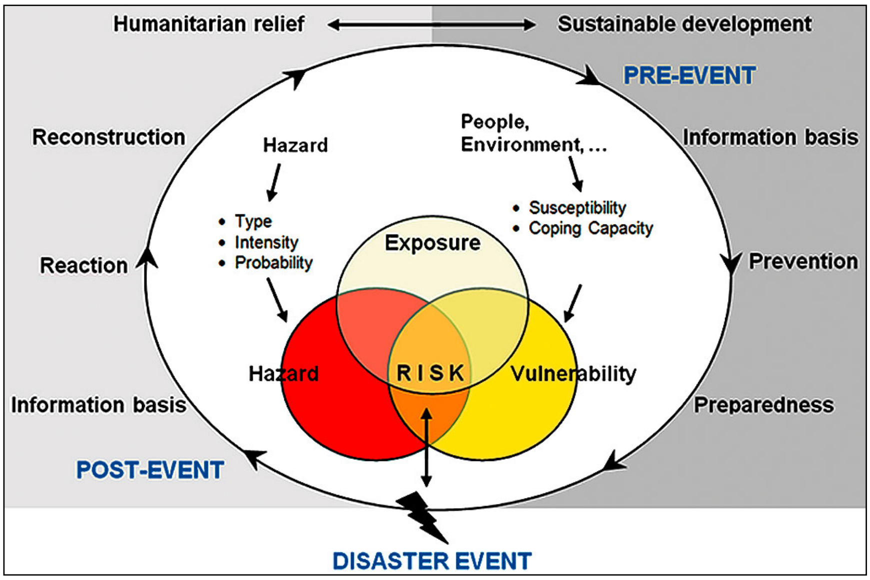

Figure 1: Risk as a result of the interaction of the hazard and the vulnerability embedded in the various phases of the disaster management cycle (adapted from Wisner, 2004; Taubenböck et al., 2008).

Conceptual foundation: hazards, exposure, vulnerabilities and risks

The concept of risk itself is subject to a vibrant debate within the scientific community. In recent years, a shift from hazard-oriented research strategies towards more integrative approaches to assessing risk and its components, incorporating also human, societal, and cultural factors, can be observed (Pelling, 2003; Taubenböck et al., 2008). This change can be related to the realisation that natural hazards do not have an intrinsic dangerous character themselves, but become disastrous if several unfavourable parameters come together. This relationship can be expressed as:

Risk = *f*(Hazard, Exposure, Vulnerability). (eq1)

Here, risks are seen as a function of the future interplay of specific hazards, exposed elements and their vulnerabilities. The '*hazard*' component in equation 1 is defined as the probability of a disastrous event happening in a certain period of time, with a particular intensity at a particular location (UNESCO, 1973). The second component, '*exposure*', is defined as the degree, duration, and/or extent to which a system is in contact with, or subject to, perturbation (Kasperson et al., 2005; Adger, 2006). The third component, '*vulnerability*', is the relationship between the system's exposure and susceptibility to a stressor with the coping capacity of the system, that is, its potential to mitigate the impact of the hazard (UN/ISDR, 2004; Birkmann, 2006).

While risks imply a potentially damaging future event, the disaster management cycle puts the conceptual idea of risk into the full cycle of the timeline (see Fig. 1): The disaster management cycle contains pre-event preparedness and disaster reaction (or response) and provides insight of the conceptual idea at different stages (Fig. 1).

The management of risks: early warning and mitigation strategies

The management of risks – independent of the time before, during, or after an event – relies on the availability of up-to-date and appropriate information (in terms of thematic, temporal, and geometric resolution). Based on these data, the assessment of hazards, exposure, vulnerability, and ultimately risks, can be conducted as a basis for formulating and implementing early-warning systems and mitigation/prevention strategies, as well as pre-event preparedness plans. Technological solutions in combination with community-centred strategies have been reported to be successful in this regard (e.g. Kelbessa, 2009; Taubenböck et al., 2009).

In addition, this kind of knowledge base is also crucial in the post-event phase. It is necessary for informing reactions (response) in terms of humanitarian relief or reconstruction strategies. For example, rapid mapping mechanisms such as from the International Charter "Space and Major Disasters", the Emergency Management Service of the European COPERNICUS program, the United Nations (UNOSAT-UNITAR), and SENTINEL ASIA, have been developed for providing fast, standardised spatial information products (Voigt et al., 2016).

However, the application of scientific findings to the mitigation of impacts holds many challenges, from issues of unclear communication and stakeholders with different interests, to stakeholders not being aware of available information (see examples of these challenges in Taubenböck et al., 2013).

The situation in southern Africa

In large parts of Africa, drought is often the most frequent climate-related disaster with devastating effects on water supply, crop production, and rearing of livestock (Masih et al., 2014; Spinoni et al., 2014). In the following chapter, drought will be examined from natural and social science perspectives. On the one hand, Müller et al. (2018) describe methods to undertake long-term analyses of droughts based on remote sensing data. In a case study, they compare the proportion of land cover classes affected by droughts of different persistency in South Africa and Botswana in 2015/2016. On the other hand, Luetkemeier & Liehr (2018) provide insights into drought sensitivity in the Cuvelai Basin of northern Namibia and southern Angola. As part of a social-ecological drought risk analysis (Luetkemeier & Liehr, under review), they empirically assess local water and food consumption patterns to identify critical water dependence structures at the household level. In combination with a recent drought hazard assessment (Luetkemeier et al., 2017), Risk management

this study provides stakeholders with a comprehensive information base for drought impact mitigation.

Besides the hazard of drought, the subsequent articles discuss the hazard of intensified exploitation of natural resources, which imposes negative effects on vital ecosystems and environments in Africa. In this regard, Olivier et al. (2018) investigate sediment movement in discontinuous gully systems in the Swartland region in the Western Cape of South Africa. They confirm that the gully systems are no relics of the past, but rather, active erosive systems that destroy fertile soils and hence undermine long-term sustainability of the farming systems. Interestingly, they find that conservation techniques such as contour ploughing can even aggravate the problem. Ferreira-Baptista et al. (2018) examine the pollution effects of mining activities on water resources in north-eastern Angola. They observe multiple negative effects on water bodies from deforestation, soil depletion, and topographic changes in nearly all of the north-eastern provinces of Angola.

Outlook

The observed climatologically-driven increase of natural hazards exposes an ever-increasing amount of area and number of people around the globe to risks. A consequence of these changing environments and related living conditions is forced migration into cities within and across borders (Davis, 2007). This leads to an additional concern: the clustering of exposed elements at risk in ever-expanding urban areas (Taubenböck et al., 2012).

These processes of global change (climate change, urbanisation, etc.) demand constant vigilance, which requires the availability of environmental and socio-economic monitoring data. Besides in-situ information, understanding the spatial inter-relationship of these processes demands geospatial (primarily remote sensing) data and methods. These have become crucial tools for monitoring and integrating information on natural and societal processes and provide decision-makers with targeted knowledge to perform adapted disaster risk mitigation tasks.

Beyond the technical aspects, which are exemplified in the following chapters of this book, one of the main challenges in the field of disaster risk reduction is to change people's perceptions so that they recognise disasters as the outcome of a process in which societies have implicitly generated vulnerabilities and risks (Villagrán de León, 2006). Or, as Rashed & Weeks (2003) put it: assessing risks and managing disastrous events is an ill-structured problem (i.e. a problem for which there is no unique, identifiable, objectively optimal solution). However, new conceptual perspectives combined with latest data and technical solutions allow a more comprehensive understanding of these complex processes.

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