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EDITORIAL

# Special issue "Adaptation to climate change: analysing capacities in Africa"

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Adapting to climate change is a challenge in Africa considering the prevailing livelihood conditions, the widespread poverty and food insecurity, the varying adaptive capacities, the weak institutional frameworks and the exposure to multiple stressors, which range from volatile financial and commodity markets and violent conflicts to extreme weather events. Adaptation is made more difficult by the complex interaction of impacts across sectors, which produces "cascading effects that are largely unpredictable" (World Bank 2012: 62). Two sets of dynamics intertwine and affect adaptation: the interactions between different biophysical impacts of global warming on the one hand (i.e. higher temperatures, changes in precipitation patterns, impacts on biodiversity), and the processes triggered by weak social systems that may be unable to compensate for sudden ecological changes and uncertainties on the other hand.

As the stabilization of greenhouse gas concentrations in the atmosphere continues to be elusive, the threats of climate change to ecosystems, food production and economic development are becoming more apparent. With the exception of areas in the northeast, drier conditions are projected for Africa. Sillmann et al. (2012) project significant increases in extreme precipitation in terms of the monthly or annual maximum of 5-day precipitation accumulations increasing by 20–30 % towards the end of the twenty-first century for Western and Eastern Africa. East Africa is projected to become generally wetter in the future, while dry conditions are to intensify significantly in Southern Africa with significant increases in consecutive dry days (Sillmann et al. 2012; cf. Batisani and Yarnal 2010). Much of Southern Africa will be affected by extreme droughts and particularly soil moisture decreases (Dai 2012). However, a simulation by Williams and Funk (2010) shows contrasting results for tropical Eastern Africa—during the twenty-first century, drier conditions, associated with warming in the Indian Ocean, are more likely than wetter conditions in the long-rains season (March–June). Thus, there is still uncertainty about how climate change will actually affect precipitation in the continent, but a varying range of impacts can be expected. The fundamental limits to climate predictability (Thornton et al. 2011) indicate the need for downscaled climate projections in Africa, yet the already projected unprecedented conditions have various implications for African social and ecological systems.

Changes in climate variables will affect water availability. Gerten et al. (2011) show that many African regions such as North and East Africa are physically water scarce, being unable to meet the water requirements of their populations. With climate and population change, water availability per person is likely to decline in these regions. While population growth is a major driver of water stress, in a +2 °C and +4 °C world, climate change would be the dominant cause of water stress in African river basins (Fung et al. 2011). Sea level rise and saltwater intrusion also threaten parts of Africa (Nicholls and Cazenave 2010).

Forests in Africa may expand in some regions while they might decline in others. In a +2 °C and +4 °C world, forest area is likely to increase in the Congo Basin, West Africa and Madagascar, although the risk of niche contraction remains mainly in the North and South of Africa (Zelazowski et al. 2011). While not all climate change

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impacts are negative, the outcomes of interactions between positive and negative impacts may lead to trade-offs. Vegetation expansion due to increased plant water efficiency attributable to increased atmospheric $CO_2$ concentrations is projected for the Congo basin, West Africa and Madagascar (Zelazowski et al. 2011). This expansion would affect biodiversity, leading, for example, to loss of savannah plant species in Southern Africa (Parr et al. 2012) and likely resulting in similar losses for east Africa (Zelazowski et al. 2011).

Thus, there is high possibility of ecosystem damage in various African ecoregions such as the South African Fynbos and the Congo River forests, which, by 2030, are likely to be regularly exposed to temperatures that were monthly extremes in the twentieth century, with all terrestrial African ecoregions affected by 2070 (Beaumont et al. 2011). This threat to Southern African biodiversity has also been reported in Midgley and Thuiller (2011). Besides exposure to climate change, other human-induced pressures such as deforestation and the capacity of the exposed to adapt may determine the magnitude of impacts.

Only 6 % of the total cultivated area in Africa is irrigated (FAO Aquastat 2005), while 94 % is rainfed, making the continent sensitive to changes in weather and climate. African economies greatly depend on agriculture, which accounts for 20–40 % of the gross domestic product (Godfray et al. 2010). Africa is also one of the regions with most pronounced reductions in arable land (ranging from 1 to 18 %) predicted to occur by the end of the twenty-first century due to climate change (Zhang and Cai 2011). With 4 °C or more of warming, 35 % of cropland in east and Southern Africa is projected to become unsuitable for cultivation (Arnell et al. 2009; cf. Jones and Thornton 2009). Although not accounting for the effect of $CO_2$ fertilization, Thornton et al. (2011) show that in a +5 °C world in the 2090s, most crop and rangelands are likely to experience major reductions in their growing season length, with declines of 13–23 and 69–87 % projected for maize and bean production across different African regions.

Further, Sub-Saharan Africa may be faced with public health and political challenges associated with climate change. It is one of the regions that may be exposed to a high malaria transmission probability rate under projected future climatic and socio-economic conditions (Béguin et al. 2011). Additionally, with Africa exhibiting the most susceptibility to climate-induced poverty among a global sample of developing areas (Ahmed et al. 2009; Hertel et al. 2010) and with a projected increased water and food scarcity due to adverse weather conditions in Africa, conflicts over land and water are likely to increase (Brown et al. 2007; Hendrix and Glaser 2007).

These various findings depict Sub-Saharan Africa as one of the most vulnerable regions to climate change.

Much of adaptation research focuses on the drivers and structures of these interactions in the pursuit of answers to very different questions: Which economic, social, cultural and political structures and factors contribute to the vulnerability of communities, population groups and societies to external stresses and shocks? Which social and institutional dimensions constitute the capacity of communities, population groups and societies to absorb shocks and changes, learn from and adapt to them and thus become resilient? How radical are the changes in the ecological system associated with a 4 °C global warming? Will human communities be able to absorb such radical and quick ecological change and will experience be of help? How will impacts be distributed geographically, within and between societies, rich and poor?

Looking beyond these questions, adaptation measures can significantly reduce losses attributable to climate change. Downscaled projections to the various African regions can better capture changes in climate, hence providing a basis for improving adaptation measures.

One of the six articles collected in this special issue focuses on downscaling the impacts of global warming for Nigeria, thereby providing a basis for finer spatial resolution, which is useful for designing adaptation measures. The other five articles present empirical research on how different actors, mostly at local levels, are adapting to the various impacts triggered by climate variability and change. These research results enrich our understanding of how socio-ecological coupled systems react to changing environmental parameters and shed light on the features of social systems that enhance or reduce resilience. As the world heads towards a global mean temperature increase well beyond 2 °C, adaptation is not an option anymore, but rather a need, which, as much as mitigation, has to be addressed.

*Abiodun* et al. (this volume) present the results of downscaling simulated impacts of climate change for Nigeria for the latter half of this century. Nigeria is the most populous country in Africa, with about 50 % of its inhabitants living in rural areas (United Nations 2012), most of them depending on rain-fed agriculture, whereby agriculture makes up about 42 % of the GDP (Federal Republic of Nigeria 2010). The study downscales simulations from nine global climate models under two emission scenarios (B1 and A2) and analyses their impacts on future climates. Under both scenarios, there are significant temperature increases over all ecological zones. This leads to a higher occurrence of extreme temperatures and more heat waves over the entire country, more frequent extreme rainfall events in the humid south and southeast and reduced annual rainfall over the semi-arid northeast. These changes are likely to increase the occurrence of floods and heavy rains in the south and southeast and of droughts in the northeast. Moreover, results show that there will be

changes in the onset of the rainy season and that precipitation patterns may change. Filling a gap in the literature on downscaling climate change models for Nigeria, the article shows the added value of downscaling studies in terms of information on future impacts of climate change, and it shows the wide range of possible climate change impacts. These impacts will make conditions for rain-fed agriculture more difficult all over the country, exacerbating the already existing problems with land degradation. Floods and heavy rains will also be detrimental for agriculture and will increase pressure on infrastructure and economic activity in densely populated urban areas in the south.

*Djoudi* et al. (this volume) analyse vulnerability to environmental changes in an area of northern Mali that was once a lake and is now covered with forest. Originally, Prosopis (*Prosopis juliflora*)—an introduced fast-growing tree species—was planted along the lakeshores to prevent siltation. After the lake dried, the vegetation expanded quickly into the former lake area. The authors use participatory research methods in order to study the vulnerability of livestock- and forest-based livelihoods to climate variability and change in two different villages. The area is inhabited by nomads who were forced into sedentarism, others who kept mobile livestock systems and by former fishermen who lost their traditional livelihood with the disappearance of the lake. The study shows the merits of a qualitative and participatory approach that focuses on the practices and representations of local communities and situates the analysis within a longer historical context, going back to the 1970s. From the rich picture which results from this analysis, three aspects may be highlighted with a view to future social consequences of processes of sudden and drastic environmental change. First, villagers affirmed that the impacts of the droughts of the 1970s and 1980s are still felt today, and the authors explain this long-lasting effect citing the fact that external support in times of crisis always focused on emergency relief and did not include measures for improving adaptive capacity. Secondly, there is a gap between the successful use of the newly planted forest as a safety net and the widespread perception that the benefits of restoring the lake would be larger than those of keeping the forest. The authors attribute this to unclear access and use rights for the forest—the forest and its resources are insufficiently integrated into the social institutions of the villages and thus cannot be perceived as a reliable safety net. Additionally, political promises from various leaders have nurtured the wish for a "return of the lake" over the past three decades, as many politicians promise, for electoral purposes, to mobilize funds to "bring the lake back". These political discourses do not incentivise long-term strategic planning around the now available forest resources and therewith contribute to a politically constructed vulnerability. Indeed, perceptions of adaptation by the vulnerable themselves could limit adaptive actions even when resources were available. Thirdly, as the environment on which livelihoods depend changes, various actors' adaptive capacities are influenced, enabling the maintenance and transition of livelihoods for some while increasing vulnerability for others in different ways. The findings of this article are overshadowed by recent events in Mali; the study area belongs to the part of the country which was occupied by Islamist fighters, and it has a history of rebellion against the Malian state "motivated in part by lost livelihood resources due to state interventions and development projects and by political marginalization in the postcolonial state" (Djoudi et al. p. xx). Adaptive capacity, so we learn, cannot grow under conditions of political unrest and violent conflict.

*Boelee* et al. (this volume) choose another perspective and analyse the impact of water storage and rainwater harvesting—an adaptive measure—on health in Burkina Faso and Ethiopia. The article demonstrates the usefulness of cross-sectoral impact studies. Generally, investment in small infrastructure, which ensures water availability for agriculture and human use in the dry season, is considered a positive adaptive measure. However, the increased open water surface may also increase the transmission of water-related diseases such as malaria and schistosomiasis. Especially for poor people with no access to health services, these diseases may cancel out the benefits of these investments. Across Burkina Faso, many small water reservoirs were built after the heavy drought of 1973/74. Today, one-quarter of the population is infected with schistosomiasis. In Ethiopia, several large and many small dams as well as 150,000 water harvesting ponds have been constructed in order to expand the agricultural area and to improve water availability, also in times of droughts. Today, about half of the population lives at risk of malaria, which is controlled with the distribution of insecticide-treated bed nets and indoor spraying. A participatory health impact assessment conducted by the authors at several locations in various African countries allowed the formulation of a number of practical recommendations for measures to reduce adverse impacts of existing and future infrastructure. The authors show that participatory methods, which involve water users and infrastructure managers, facilitate knowledge sharing and the development and implementation of location-specific adaptations.

*Ifejika Speranza* (this volume) analyses an important feature of resilience—the buffer capacity—of agro-pastoral farm households applying conservation agriculture practices in a region in Kenya. This study combines household surveys to identify the social, economic and ecological benefits of a range of conservation agriculture practices, as perceived by smallholders, using statistical analysis to detect clusters of practices associated with those benefits.

The study identifies the clusters of practices to include soil protection, adapted crops, intensification/irrigation, mechanisation and livelihood diversification. Results from the study highlight positive inter-linkages between economic, social and ecological spheres of adaptation—maintaining or increasing production despite drought not only improved farmers' food security but also their self-esteem and social status in the community. Additionally, trade-offs between crop protection and weed management on the one hand and farmers' concern about human and environmental health effects of fertilisers, herbicides and pesticides on the other hand indicate that appropriate handling of these inputs needs to be promoted among the farmers. Conceptually, the study shows inter-linkages between the three resilience components—buffer capacity, self-organization and learning—through practices by which farmers learn and exchange the acquired knowledge with other farmers in their groups. Through the conservation agriculture practices, farmers improved their productivity and incomes despite drought and enhanced their environment and their social relations. However, the results also hint at potential socio-economic costs for a rural economy should better-off farmers no longer employ poorer farmers due to labour savings arising from conservation agriculture.

*Washington-Ottombre and Pijanowsky* (this volume) contribute another empirical study of adaptive practices employing participatory methods. They examine the role of local rural institutions (LRI) and thus of collective action in shaping adaptation strategies in three different villages on the eastern slopes of Mount Kenya, situated along a climatic gradient. The three villages are characterized by different climatic, pedologic and socio-economic conditions (poor communities vs. well-off communities that rely on export crops). All of them suffered a 2-year drought, which reduced food crop harvests considerably as well as from the economic crises and the political measures (land evictions, re-districting) following the tumultuous elections in Kenya in 2007. The empirical research is based on household interviews in all three communities and on role games with groups in the two better-off villages that helped identify coping and adaptation strategies to climate change (defined as recurrent droughts) and the role of collective action through LRIs therein. In addition, the level of household participation in LRIs was measured, and the relevant factors for explaining differences in connectedness were identified using statistical analysis. With regard to LRIs, the authors distinguish formal institutions which follow a pre-set organizational pattern such as cooperatives from so-called rural producer organizations (RPOs) which are of a location-specific and bottom-up character and congregate neighbours (or kin) in self-help groups. The results show that farmers are able to respond to enduring change in climatic conditions with creative strategies for diversifying their livelihoods and disconnecting their sources of income from climate-dependent activities. It became clear that members of the richest village were able to rely on cooperatives and banks to respond to short-term climate disturbances, while farmers from the poorest village relied on their experience with RPOs to develop long-term adaptation strategies. However, the level of social connectedness and of participation in RPOs was particularly low among poor households characterized by very young or very old family members and low levels of education. With regard to resilience, the study shows the importance of the rich interactions between local officials and RPOs, which create a polycentric web of local collective action.

*Herrfahrdt-Pähle* (this volume) considers a conceptual question by analysing how far Integrated Water Resource Management (IWRM) is able to address issues of adaptation to climate variability and change and the additional features required for increasing the adaptability of water governance and management. The author concludes that the features of IWRM and adaptive water governance include both synergies and trade-offs which play out differently in different combinations and contexts. The article substantiates the insight that integrated resource management approaches are not per se prepared to tackle the challenges of climate variability and change, and that these need to be actively considered in order to reduce vulnerability of governance institutions and management procedures. To give an example, IWRM as a planning tool emphasizes use efficiency and policy coherence while adaptive governance requires flexible procedures and redundant institutions in order to deal with uncertainty. Thus, the appropriate levels of efficiency and redundancy in water management need to be identified in a context of uncertain and worsening hydrological conditions and increasing demand. A special emphasis is put on participatory, transparent and accountable governance structures that contribute to trust building and to the predictability of the social system, thus compensating for the increase in uncertainty of ecological conditions.

This conceptual analysis is then applied to South African water legislation and management practices, which reveal a number of weaknesses. Past approaches for securing water availability relied on large infrastructures (dams and canals); these might be too inflexible for future hydrological conditions, and they underestimate the benefits of introducing radical innovations such as catchment management (whose decentralized structures compete with the province offices of the Department of Water Administration), demand management and ensuring adequate water volumes for environmental flows. Management and adaptation challenges are exacerbated by the legacy of Apartheid: pressures on scarce water resources increase due to the need to socially and economically include the black majority, which in the short-term makes water

management appear to be an engineering and financial challenge, obfuscating the need for environmental foresight. At the same time, water administration is weakened by the lack of well-educated and well-experienced black water managers and the retirement of experienced (white) staff. Introducing such governance and management innovations requires high investment in the short term, while benefits will only be realized in the future. The inability to put these changes in place perpetuates today's weaknesses into the future, with social and economic costs much higher than today's investment.

The studies in this volume show that understanding how local, national and regional actors adapt to climate variability and change can contribute positively to adaptation planning and practice. Knowledge on regional climate changes, adaptation practices, lessons learned, needs and gaps allows for more targeted improvement of adaptation practices and support for adaptation in Africa. More empirical research will be needed to understand successful cases of adaptation. Learning from failures will also be necessary, with a view to identifying the social, economic, political and institutional causes of non-adaptive social systems. This will be especially important with regard to the feedback effects between mitigation and adaptation strategies, an area which is very little understood as yet but will gain in importance in the future.

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