On Rains, Raids and Relations: A Multimethod Approach to Climate Change, Vulnerability, Adaptation and Violent Conflict in Northern Africa and Kenya

Dissertation

zur Erlangung des Doktorgrades
der Naturwissenschaften im Fachbereich
Geowissenschaften der Universität Hamburg

vorgelegt von

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aus Hamburg

Hamburg, 2012

Als Dissertation angenommen vom Fachbereich Geowissenschaften
der Universität Hamburg auf Grund der Gutachten

von Prof. Dr. Jürgen Scheffran

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Hamburg, den 10. Juli 2012

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Eidesstattliche Erklärung

Hiermit erkläre ich, dass die vorliegende Arbeit ohne fremde Hilfe, selbstständig und lediglich unter Benutzung der aufgeführten Hilfsmittel angefertigt wurde.

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Zusammenfassung

Der Klimawandel ist eine der größten Herausforderungen unserer Zeit. Dürren, Fluten und Stürme können zu Ressourcenknappheit führen und ganzen Bevölkerungsgruppen die Lebensgrundlage entziehen. Zunehmend wächst die Befürchtung, dass sich der Klimawandel zu einem „Bedrohungsverstärker" entwickelt, der ein Risiko für die menschliche Sicherheit darstellt. Dieses Risiko ist größer in Regionen mit starker Abhängigkeit von natürlichen Ressourcen und geringer Anpassungsfähigkeit an Klimaveränderungen. Afrika zählt zu diesen Regionen. Die Mehrheit der afrikanischen Bevölkerung und insbesondere die ärmeren Bevölkerungsschichten betreiben Wanderviehwirtschaft (Pastoralismus) und Ackerbau, um ihren Bedarf an Nahrung und Einkommen zu sichern.

Diese Doktorarbeit untersucht die komplexen Zusammenhänge zwischen Klimawandel, Verwundbarkeit (Vulnerabilität), Anpassung (Adaption) und gewalttätigen Konflikten im nördlichen Afrika und Kenia. Um der Gesamtkomplexität gerecht zu werden, verbindet die Untersuchung sieben Studien, in denen eine Vielzahl von Methoden auf verschiedenen geographischen Ebenen und über disziplinäre und kulturelle Grenzen hinweg zum Einsatz kommt.

Die erste Studie gibt einen Überblick über die Klimawandel- und Konfliktliteratur um daraufhin zentrale Herausforderungen und Forschungsfragen zu identifizieren. Die Forschung befindet sich noch in einem frühen Stadium. Einige Studien haben einen Zusammenhang zwischen klimatischen Bedingungen und Konflikten gefunden während andere Studien dies nicht konnten. Die wesentliche Herausforderung der Forschung besteht darin, Datenquellen zu erschließen, die in der Lage sind lokale, nichtstaatliche Konfliktdynamiken raumzeitlich zu erfassen und diese in die Gesamtkomplexität der Thematik einzubetten. Dies wird in der vorliegenden Doktorarbeit versucht indem die Analyse von substaatlichen Konflikt- und Klimadaten unter Verwendung von akteurszentrierten Ansätzen mit qualitativer Feldforschung verbunden wird.

Hierzu werden in der zweiten Studie zunächst die Theorien, Konzepte und Modelle eingeführt, die nötig sind um Beziehungen zwischen Klima und Sicherheit zu verstehen. Ein konzeptioneller Rahmen wird entwickelt als Grundlage für ein agentenbasiertes Modell, mit dessen Hilfe dann potentielle Konfliktkonstellation zwischen Anrainerstaaten des Nilbeckens diskutiert werden.

Die dritte Studie untersucht klimatische Veränderungen, Vulnerabilität, Adaption und Konflikte in Nordafrika mit Fokus auf Marokko. Es zeigt sich, dass Nordafrika dem Klimawandel gegenüber sehr verwundbar ist. Die Gründe für die Vulnerabilität unterscheiden sich jedoch von Staat zu Staat. Wasserknappheit, Abhängigkeit von niederschlagsbasierter Landwirtschaft, Bevölkerungswachstum und Korruption stellen generelle Herausforderungen für die Anpassung an ein trockener werdendes Klima dar. In Marokko zeigen Klimasimulationen und ein bio-ökonomisches Modell, dass es empfehlenswert ist, die Primärproduktion der Landwirtschaft von Ertragsmaximierung hin zu Ertragsstabilisierung neu auszurichten. Weiter deutet die Analyse von sozioökonomischen Kenngrößen sowie Klima- und Konfliktdaten darauf hin, dass Algerien, Ägypten und Marokko am anfälligsten für Klima beeinflusste soziale Instabilitäten sind.
Die darauffolgende Studie beschäftigt sich explizit mit sozialen Instabilitäten im nördlichen Afrika. Die Analyse der Konflikte zwischen Bauern und nomadischen Viehhaltern (Pastoralisten) in Mali zeigt, dass der Klimawandel eine begrenzt konfliktverstärkende Rolle spielt. Aufbauend auf dieser Feststellung und den zuvor eingeführten Modellen entwickelt die Studie einen Konzeptrahmen, der auf weitere Konflikte zwischen Bauern und Pastoralisten angewendet werden kann.
Die letzten drei Studien beschäftigen sich mit Klimawandel und Konflikten zwischen Pastoralisten in Kenia. Über einen Zeitraum von fünf Monaten hat der Autor im ariden Nordwesten Kenias mit zwei Gruppen von Pastoralisten, den Turkana und den Pokot gelebt, um die gewalttätigen Konflikte der Gruppen um Wasser, Land und Vieh zu untersuchen. Verschiedene qualitative Forschungsmethoden, wie Interviews mit Gruppenmitgliedern (u. a. Viehhirten, Dorfälteste, Frauen, Jugendliche), Expertengespräche, Fokusgruppendiskussionen und teilnehmende Beobachtungen wurden angewendet.
Die Konflikte stehen in engem Zusammenhang mit gewalttätigen Viehdiebstählen, dem so genannten “raiding”. Die Motive des raidings reichen von Dürre und Armut über Zahlung von Brautsteuer bis hin zu territorialer Erweiterung. Weitere Konfliktfaktoren sind politische und sozioökonomische Marginalisierung, Kommerzialisierung des raidings und die weite Verfügbarkeit von automatischen Handfeuerwaffen.

Gestützt auf die Analyse von Klimadaten und einzigartigen Aufzeichnungen von raiding Vorfällen wird eine Hypothese entwickelt, die den Zusammenhang zwischen raiding während Trockenphasen und während Regenzeiten erklären könnte.

Klimaprojektionen deuten auf ein wärmeres, insgesamt regenreicheres aber weniger zuverlässiges und vorhersehbares Klima in Kenia hin. Dies wird es Pastoralisten wahrscheinlich erschweren Wasser- und Weideressourcen zu nutzen. Zudem gerät die Lebensgrundlage der Pastoralisten durch die Auswirkungen der bewaffneten Konflikte unter Druck.

Die Konfliktauswirkungen werden genauer diskutiert, zusammen mit der Frage was getan werden kann, um die Gewalt zu verringern und eine konfliktsensitive Klimaanpassung zu fördern. In diesem Zusammenhang sind die Gewährleistung von sicherer und freier Mobilität der Pastoralisten und ihrer Viehherden sowie die Stärkung von lokalen Institutionen wichtig.

Einige Punkte von genereller Bedeutung gehen aus der Doktorarbeit hervor. Die komplexen Zusammenhänge zwischen Klimawandel und Konflikt können nur verstanden werden, wenn zuvor Fragen der Vulnerabilität und Adaption beantwortet werden. Die Komplexität der Thematik macht es erforderlich einen interdisziplinären Mehrmethodenansatz anzuwenden.

Die internationale Gemeinschaft muss ihre Bemühungen verstärken, den Ausstoß von Treibhausgasen zu begrenzen, um das Potential des Klimawandels zu reduzieren als Multiplikator von Sicherheitsrisiken zu wirken. Weiter sollte die internationale Gemeinschaft konfliktsensitive Klimaanpassung in Entwicklungsländern unterstützen. In Ländern, in denen Wanderviehwirtschaft betrieben wird, ist es für die nationalen Regierungen wichtig, Pastoralismus als produktive Lebensgrundlage anzuerkennen, die gut an die rauen klimatischen Bedingungen von ariden und semiariden Räumen angepasst ist. Dies bedeutet vor allem traditionelle und lokale Institutionen zu respektieren, sie in nationale Politiken zu integrieren und den Pastoralisten und ihren Viehherden sichere Bewegungsfreiheit zu ermöglichen.

Abstract

Climate change is one of the greatest challenges that the world is facing today. Droughts, floods and storms can lead to resource scarcity and undermine entire livelihoods. Concerns are increasing that climate change may act as a "threat multiplier" which poses a risk to human security. The risk is higher in regions where the dependence on natural resources is strong and the adaptive capacity to climatic changes is low. Africa is such a region. The majority of the continent's population, particularly the poor, depend on pastoralism and agriculture for food and income security.

This thesis analyzes the complex relations between climate change, vulnerability, adaptation and violent conflict in northern Africa and Kenya. To grasp this complexity, the thesis combines seven studies, applying a multitude of research methods at different geographic scales and across disciplinary and cultural boundaries.

The first study reviews the existing literature on climate change and conflict to identify core research challenges and questions. This research field is still in its early stage. Some studies have found a correlation between climatic conditions and conflict while others have not. The major research challenge is to collect and utilize spatiotemporal data which is able to capture local, non state conflict dynamics, and to integrate this data into the overall complexity of the research matter. To address this challenge, the thesis uses agent-centered approaches to combine the analysis of local conflict and climate data with qualitative field research.

The theories, concepts and models needed to understand climate-security interactions are introduced in the second study. Here, a conceptual framework is developed for an agent-based model which is then used to discuss potential conflict constellations between the states of the Nile river basin.

The third study analyzes climatic changes, vulnerability, adaptation and conflict in North Africa with a focus on Morocco. The results show that North Africa is highly vulnerable to climate change but the reasons for the vulnerability differ from state to state. Water scarcity, dependence on rain fed agriculture, population growth and corruption are challenges for adaptation to an increasingly drier climate. In Morocco, the applied climate simulation and the bio-economic model show that a shift in agricultural production from maximization to stabilization of output is recommendable. The analysis of socioeconomic, climate and conflict data shows further that Algeria,

Egypt and Morocco are the countries most prone to climate change related social instabilities.

The next study focuses specifically on social instabilities in northern Africa. The discussion of conflicts between farmers and herders in Mali shows that climate change contributes to these conflicts, although to a limited extent. Based on this finding and the models introduced earlier, the study develops a conceptual framework which can be used to explore other farmer-herder conflicts.

The last three studies focus on climate change and violent inter pastoral conflicts in Kenya. Over a period of five months the author has lived in arid northwestern Kenya with the two pastoral groups, Turkana and Pokot, to analyze their violent conflicts over water, land and livestock. A variety of qualitative research methods including interviews with community members (e.g. pastoralists, elders, women, youth) and experts, focus group discussions and participating observations was applied.

The conflicts are closely related to violent livestock thefts, termed "raiding". The identified motives for the raiding range from drought and poverty to payment of dowry and the expansion of territory. Other factors contributing to conflict include political and socioeconomical marginalization, commercialization of raiding and the availability of automatic small arms. Based on the analysis of climate data and a unique record of raiding incidences, a hypothesis is developed which could explain the relation between raiding during drought and during rainy periods.

Climate projections suggest a warmer, overall wetter but less predictable and reliable climate for Kenya. This is likely to increase difficulties for pastoralists to utilize pasture and water resources. Additionally, the pastoral livelihoods are under pressure from the effects of the armed conflicts.

The effects are discussed in detail together with the question of what can be done to mitigate violence and to promote conflict sensitive adaptation to climate change. In this context, ensuring safe and free pastoral movement and strengthening of local institutions is important.

Several overarching conclusions can be drawn from this thesis. The complex relations between climate change and conflict can only be understood if questions of vulnerability and adaptation are answered first. The complexity of the research matter calls for an interdisciplinary multimethod approach.

The international community needs to increase its efforts to limit greenhouse gas emissions to minimize the potential of climate change to act as a multiplier of security risks. Further, the international community should increase its support for conflict sensitive climate change adaptation in developing countries. In countries where pastoralism is practiced it is important for the national governments to acknowledge pastoralism as a productive livelihood which is well-adopted to the harsh climatic conditions of arid and semi arid lands. This implies to respect traditional institutions, to integrate them into national policies, and to ensure safe and free pastoral mobility.

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Abbreviations

ABM	agent-based modeling
ACLED	Armed Conflict Location and Event Data
AR4	Fourth Assessment Report (of the IPCC)
ASALs	arid and semi arid lands
BRIC	Brazil, Russia, India, China
CEWARN	Conflict Early Warning and Response Mechanism
CIA	Central Intelligence Agency
CNA	Center for Naval Analyses
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRA	Commission on Revenue Allocation
CRED	Centre for Research on the Epidemiology of Disasters
CSF	Contest Success Function
DMI	Drought Mitigation Initiative
ECHAM	European Centre Hamburg Model
EIDHR	European Instrument for Democracy and Human Rights
EM-DAT	Emergency Disasters Database
ENCOP	Environment and Conflicts Project
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGD	focus group discussion
FoEME	Friends of the Earth Middle East
GCM	General Circulation Model
GDP	gross domestic product
GHG	greenhouse gases
GoK	Government of Kenya
HDI	Human Development Index
HWSI	Hydrological Water Stress Index

ICE	Inventory of Conflict & Environment
IEA	International Energy Agency
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPI	International Peace Institute
KHRC	Kenya Human Rights Commission
KNBS	Kenya National Bureau of Statistics
KOSIMO	database of the Heidelberg Institute for International Conflict Research
KSH	Kenyan Shilling
MENA	Middle East and North Africa
mts	metric tons
NGO	non governmental organization
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
PMV	Plan Maroc Vert (Green Morocco Plan)
ppm	parts per million
PPP	Purchasing Power Parity
PRB	Population Reference Bureau
PRIO	Peace Research Institute Oslo
RAST	Resource Abundance and Scarcity Threshold
REMO	Regional Model
RWPI	Reversed Water Poverty Index
SIM	Security in Mobility
SNA	social network analysis
SPSS	statistical package for social sciences
SRES	Special Report on Emissions Scenarios
SST	sea surface temperature
SWSI	Social Water Scarcity Index
TUPADO	Turkana Pastoralist Development Organisation

UCDP	Uppsala Conflict Database Program
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
US	United States of America
USADF	United States African Development Found
USAID	United States Agency for International Development
USD	US Dollar
USDS	United States Department of State
VCAPS	Values and Capabilities of Action paths and Priorities in System environments
VSF-Belgium	Vétérinaires Sans Frontières-Belgium
WHO	World Health Organization
WBGU	German Advisory Council on Global Change
WMO	World Meteorological Organization
WPI	Water Poverty Index

Variables

Variables in the framework of climate-society interaction

C	climatic variables
G	greenhouse gas concentration
H	human security as a function of capability, values, and resources
N	natural resources
S	societal stability
T	temperature

Variables in the VCAPS model framework

A^k	action paths
C	capabilities
F	destructive forces to threaten, damage, or capture assets
G	pollution stock (e.g. atmospheric carbon concentration)
H	human capital
i, j…n	index of actors
K	physical capital
L	population size of social actor
M	migrating or displaced population
N	natural resources
P	action priorities
Q	goods produced in the production process
S	social capital
V	values
*V**	goals
W	wealth
X	system environment variable
Δ*C*	efforts
Δ*G*	environmental pollution
Δ*N*	changes in natural resource stocks
Δ*P*	action rules
Δ*W*	invested wealth

1. Introduction

It is getting warmer. Between 1906 and 2005 the global average temperature has increased by 0.74 degrees Celsius (IPCC 2007b). Consensus in the scientific community has been reached that the warming is predominantly “man-made” (Bray 2010, IPCC 2007a, see also Ratter et al. 2012). Anthropogenic activity, especially the emission of greenhouse gases (mainly carbon dioxide and methane), and land cover changes such as deforestation have intensified the greenhouse effect and altered the earth’s energy balance at rates unprecedented in human history (van der Werf et al. 2009). We have realized that abstract “climate change” can have severe “down-to-earth” effects. Droughts, floods and storms pose a risk for human livelihoods across the globe (IPCC 2012). Despite these risks, the international community has failed to limit the emission of greenhouse gases and to prevent unsustainable land use changes (Foley et al. 2005, IEA 2012, ter Steege 2010). The concentration of carbon dioxide has risen from 299.7 ppm (parts per million) in 1910 to 393.9 ppm in March 2012 (NOAA 2012). Considering the population and economic growth rates of the many developing countries, foremost the BRICs (Brazil, Russia, India, China), it is highly unlikely that a global warming beyond the 2 degrees Celsius target can still be prevented (IMF 2012, WBGU 2009). The current emission trajectory rather suggests that the world will experience a warming of more than 3 degrees Celsius by the end of this century (de Boer in Times 2012). In its forecast for 2052, the Club of Rome even concludes that “over-consumption and short-termism” could threaten the survivability of “humankind” (Club of Rome 2012).

While such extreme scenarios are the exception, it is widely acknowledged that climate change has the potential to overwhelm the adaptive capacity of vulnerable populations (IPCC 2007a). Further, concerns have been raised, particularly by politicians and think tanks, that climate change can act as a “threat multiplier” (CNA (CNA 2007:3) which undermines human security (see also Gleditsch 2012, Scheffran et al. 2012c). “It is vital to German foreign policy to ameliorate the security risks posed by climate change” (Westerwelle 2011a). US President Barack Obama warns that “if we do nothing, we will face more drought, famine and mass displacement that will fuel more conflict for decades” (Obama 2009). The influential Stern Review states “climate-related shocks have sparked violent conflict in the past” (Stern 2006:vii). UN Secretary-General Ban Ki-moon claims that climate change “not only exacerbates threats to international peace and security; it is a threat to international peace and security" (UN 2011).[1] "Climate wars" have been predicted in popular media (see Dyer 2011, Mazo 2010, Paskal 2010, Welzer 2009 and Oßenbrügge, 2011 for a review). The underlying assumption is that rising temperatures and altered rainfall patterns reduce the availability of natural resources which in turn leads to conflicts among the resource users, particularly in vulnerable, already conflict affected regions of the world (CNA 2007, European Commission 2008, IPCC 2007a, Smith and Vivekananda 2007, Stern 2006, WBGU 2008, Westerwelle 2011b). Africa is such a region (Busby et al. 2012, IPCC 2007a, 2012). Many African states are either vulnerable to climate change, have a history of armed conflicts or face a double exposure of both climate change and conflict (Figure 1.1).

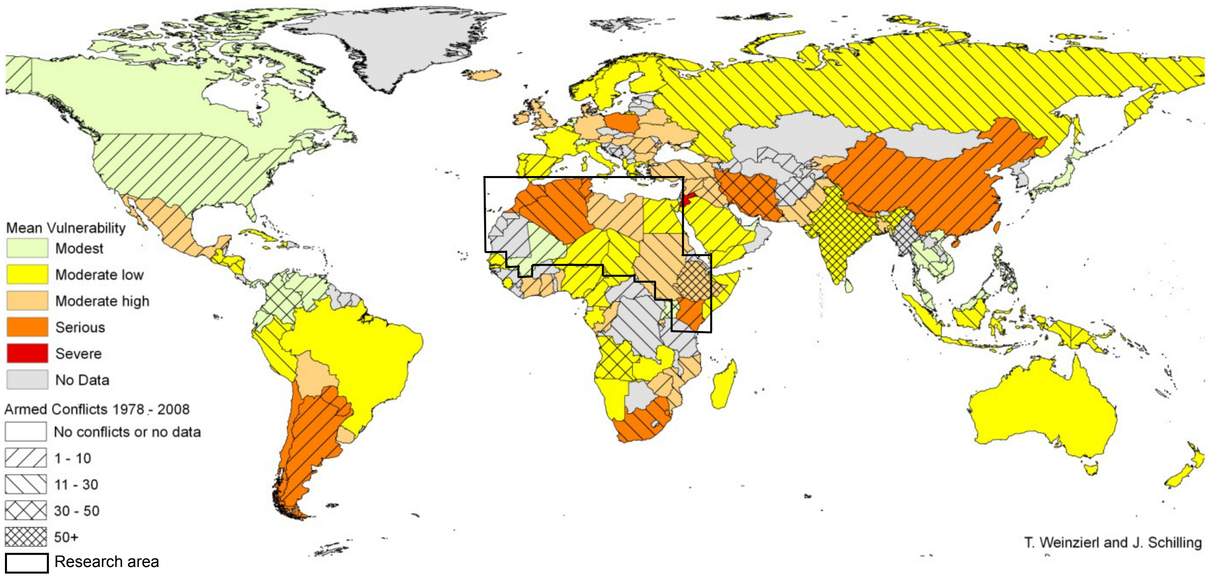

Figure 1.1 Global distribution of mean vulnerability to future climate change, number of recent armed conflicts and research area (Thomas Weinzierl and the author, see also Scheffran et al. 2012e). The vulnerability shown is the mean between the vulnerability index for climate sensitivities of 1.5°C and 5.5°C, both calculated for the IPCC A2 emission scenario until 2050 (Yohe et al. 2006b). The vulnerability index is a measure of climate change exposure, sensitivity, and adaptive capacity (for details see Yohe et al. 2006a, Yohe et al. 2006b). The conflict data are from UCDP/PRIO Armed Conflict Dataset v.4-2011 (PRIO 2011a)

While the causes of the conflict are highly diverse (e.g. Oßenbrügge 2009, Theisen et al. 2012), the continent's vulnerability to climate change can generally be attributed to the strong exposure and sensitivity to climate change and the limited adaptive capacity (Busby et al. 2012, IPCC 2007a, 2012). Over the past hundred years warming on the African continent has been larger than the global annual mean. It is "very likely" that this trend continues "throughout the continent and in all seasons"

[1] For a discussion of the securitization of climate change see Oels (2012).

(IPCC 2007a:866). The population of the African continent is sensitive to climate changes because of the strong dependence on rain fed agriculture for food security and income generation (FAO 2012, Schilling et al. 2012c). Widespread poverty and corruption limit the adaptive capacity of many states on the African continent (Transparency International 2011, World Bank 2012).

1.1 Objective and Research Questions

Against the background of intensifying climate change and rising security concerns, it becomes increasingly important to understand the effects of climate change on human livelihoods, especially in Africa. The effects can only be understood if the vulnerability and adaptive capacity of the affected group is explored first. So far, the majority of research publications have focused on climate change and its interrelation with one or two of the aforementioned variables. To the author's knowledge this is the first time that the relations between climate change, vulnerability, adaptation and violent conflict are analyzed in one doctoral thesis covering such a large geographic region (see Figure 1.1).[2] The research region of 14 states of northern and eastern Africa[3] was chosen to cover a variety of attributes with respect to the level of development, projected climatic changes as well as conflict type and intensity. The income levels range from high in the case of Libya (14,364 US$ per capita) to very low in the case of northwestern Kenya (171 US$ per capita) (UNDP 2006, 2009). Northern Africa is expected to experience drier conditions while for East Africa increases in annual rainfall amounts are projected (Schilling et al. 2012b, Schilling et al. 2012c).

The analyzed conflict types include potential interstate conflicts in northern Africa and the states of the Nile river basin, as well as existing intrastate state conflicts in Mali and Kenya. In the inland Niger delta of Mali the focus is placed on violent pastoralist-farmer conflicts while in northwestern Kenya highly violent inter pastoral conflicts are analyzed in detail. These two types of conflicts have a strong resource component and mostly occur in arid and semi arid areas (ASALs) which cover about 40% of the earth's land surface and host an estimated one third of the world's population (GoK

[2] Recently Freier (Freier 2011) analysed the impacts of climate change on alternative land use regimes and adaptation but the geographic focus was limited to Morocco and four other North African states.

[3] These include Morocco, Algeria, Tunisia, Libya, Egypt, Western Sahara, Mauritania, Mali, Niger, Chad, Sudan, Ethiopia, Uganda and Kenya.

2007, Raleigh 2010, UN 2010). Worldwide about 120 million people (50 million in sub-Saharan Africa) practice pastoralism and agro-pastoralism (Rass 2006). Hence, the findings of this study are likely to be relevant beyond the boundaries of the research region. This also applies to the following specific research questions which the thesis attempts to discuss.

- What are the major research challenges and questions that need to be addressed to understand human-environment interactions?
- What are instrumental theories, concepts and models, and how can they be applied to specific problems of climate-security interactions?
- How vulnerable is North Africa and for which reasons?
- What are options for adaptation to climate change in Morocco?
- What role does climate change play in agro-pastoral conflicts in Mali and pastoral conflicts in Kenya? What are the similarities and differences?
- What are the key motives and factors driving the pastoral conflicts in northwestern Kenya?
- How do the conflicts affect pastoral livelihoods?
- How can the conflicts be mitigated?
- How can sustainable adaptation to climate change be promoted?

The listed questions are all related and each in itself highly complex which adds up to a challenging overall complexity. To grasp this complexity, a multitude of research methods needs to be applied at different geographic scales and across disciplinary and cultural boundaries (see also Schilling et al. 2010).

1.2 Methods and Scales

Both quantitative and qualitative methods are applied in this thesis. The quantitative methods include different types of modeling and statistical analysis. On a regional scale, the VCAPS (Values and Capabilities of Action paths and Priorities in System environments) model is used to simulate potential constellations of water conflicts between the countries of the Nile river basin. On a national scale, socioeconomic and conflict data is analyzed to explore the climate change vulnerability and conflict potential of five North African states. Further, on the national scale, climate modeling is utilized to project future water availability for Morocco and Kenya. On a local scale, a bio-economic model is used to explore the responses of pastoralists to different levels of precipitation in a province of central Morocco. In the inland Niger delta of Mali, a first model framework is presented to improve the understanding of conflicts between farmers and herders[4]. In northwestern Kenya climate data is analyzed in conjunction with two sets of conflict records. First, the intergovernmental conflict dataset of CEWARN (Conflict Early Warning and Response Mechanism) to which few researchers had access so far. And second, the unique conflict records of the non governmental organization TUPADO (Turkana Pastoralist Development Organisation) which, to the author's knowledge, is utilized for the first time in a scientific study.

While the modeling in this thesis was mostly conducted by collaborating researchers, the statistical analysis and particularly the qualitative methods were applied by the author of this thesis during the field research. In March and from September to December 2011, the author interviewed 164 community members and representatives of governmental and non governmental organizations (NGOs) in Kenya. The interview types included semi structured expert interviews, open and small group interviews as well as focus group discussion with mostly pastoralists, raiders, elders, women and chiefs (see Appendix C and D).

These methods were supplemented by participating and non participating observations which where conducted while the author lived with both conflict parties in northwestern Kenya, partly under challenging security and climatic conditions (Appendix D).

1.3 Structure

The thesis is structured along seven publications (four journal articles and three book chapters) of which the author of this thesis was either the lead author or has contributed a significant part to the content.[5] To satisfy the interdisciplinary requirements of the research matter, the thesis combines geography approaches with perspectives from different disciplines including (geo-)ecology, meteorology, soil and agriculture science, peace and security studies, political sciences, economics and sociology. To ensure comprehension of local perspectives, all publications on Kenya were written in collaboration with Kenyan researchers.

[4] The terms herders and pastoralists are used synonymously in this thesis.
[5] Details are given in a footnote at the beginning of each chapter.

Thematically, the thesis is divided into three parts: (I) Background, theories and models (Chapter 2 and 3), (II) Northern Africa (Chapter 4 and 5) and (III) Kenya (Chapter 6 through 8). Each chapter builds on the prior one(s) but the chapters can also be read independently as each chapter pursues a specific objective.

The objective of Chapter 2 is to review the existing literature on climate change and violent conflict, and to identify core research challenges and questions associated with the study of human-environment interactions.

These interactions are then discussed in-depth in Chapter 3 which introduces the key theories and concepts. Further, a model framework of climate-security interactions is developed and applied to potential water conflicts between the countries of the Nile river basin.

Chapter 4 begins with a regional focus on climate change, vulnerability and conflict sensitivity in Algeria, Egypt, Libya, Morocco and Tunisia. The focus is then narrowed down to Morocco to discuss impacts of climate change on agriculture and societal stability in conjunction with options of adaptation. This chapter combines climate modeling with an analysis of socio-economic vulnerability and modeling of local responses to altered rainfall amounts.

In Chapter 5 the geographic focus is extended south to incorporate Western Sahara, Mauritania, Mali, Chad, Niger, and Sudan.[6] While the vulnerability to conflicts is briefly assessed for all countries, the role of climate change in conflicts between herders and farmers in the Niger delta of Mali is discussed in more detailed. Based on the discussion a first model framework is drafted which could support the analysis of other herder-farmer conflicts.

Chapter 6 through 8 address various aspects of pastoral conflict and climate change in northwestern Kenya. The conflicts are closely related to the forceful acquisition of livestock, termed raiding. Based on the analysis of climate and raiding data, and supplemented with qualitative research, a hypothesis is developed which could explain contradictory findings on the occurrence of raiding during periods of resource scarcity and during periods of resource abundance (Chapter 6). In line with the example of Morocco, options of adaptation to climate change and policy implications are then discussed.

The following Chapter 7 takes the analysis of climate change and conflict a step further by showing how the conflicts affect pastoral livelihoods. The negative effects

[6] Chapter 5 is based on a publication which was written prior to the independency of South Sudan.

of the conflicts reach an extent which undermines the adaptive capacity and ultimately the survivability of pastoral communities.

While all chapters on Kenya explore the motives, drivers and mitigation measures to varying degrees, Chapter 8 focuses specifically on the potential benefits and challenges of conflict mitigation mechanisms.

The last chapter summarizes the key findings of the previous chapters with respect to the research objective and questions. Conclusions are drawn to inform further research and to provide policy recommendations.

PART I BACKGROUND, THEORIES AND MODELS

2. Climate Change and Violent Conflict[7]

Since publication of the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the debate on the security implications of climate change has intensified. Research in this area has made progress but remains controversial (for recent reviews, see Bernauer et al. 2012, Gleditsch 2012, Scheffran et al. 2012d). Although some quantitative empirical studies support a link between climate change and violent conflict, others find no connection or only weak evidence.

A major challenge for all studies is to find adequate data. Instead of using data on the long-term average and variability of temperature, precipitation, and other climatic variables that would clearly fall under the IPCC definition of climate change (IPCC 2007b), many studies have used proxies, such as short-term data on weather and extreme weather events, or on natural phenomena of climate variability like the El Niño Southern Oscillation (Hsiang et al. 2011).

It is important to distinguish between the types of conflict used in various data sets. The widely used Armed Conflict Dataset of the Uppsala Conflict Data Program and the Peace Research Institute Oslo (UCDP-PRIO), for instance, sets a minimum of 25 battle-related deaths per year and involvement of at least one state government to be considered as armed conflict (PRIO 2011b). This excludes other forms of violent or non violent behavior that may be affected by climate change such as protests, riots, or livestock theft, let alone conflict as a positional difference over interests, values, or goals. These distinctions are relevant as, in recent decades, climate variability may have been more associated with low-level violence and internal civil war—which fall below the UCDP-PRIO definition cutoff—than with armed conflict or war between countries.

Long-term historical studies tend to find a coincidence between climate variability and armed conflict, in line with some narratives about the evolution and collapse of civilizations (e.g. Kuper and Kröpelin 2006). For instance, Zhang and others (2011) combine a set of variables for the time period 1500–1800 to identify climate change as a major driver of large-scale human crises in the northern Hemisphere. Tol and Wagner (2010) cautiously conclude that, in preindustrial Europe, cooler periods were

[7] This chapter has been published in the peer reviewed publication Scheffran, Jürgen, Brzoska, Michael, Kominek, Jasmin, Link, P. Michael, Schilling, Janpeter, 2012. Climate Change and Violent Conflict. Science 336, 869-871. After the lead author, Jürgen Scheffran the co-authors are listed alphabetically. Janpeter Schilling has contributed at least 20% of the chapter's content, for instance the sections on food riots and changing rainfall patterns.

more likely to be related to periods of violence than warmer phases. Similar findings have been presented for eastern China (Zhang et al. 2007a).

However, the results have been less conclusive for recent periods. For instance, in one study, a significant correlation between temperature and civil war in Africa between 1981 and 2002 is used to project a substantial climate-induced increase in the incidence of civil war in Africa until 2030 (Burke et al. 2009). Yet, this result is not robust for an extended time period and alternative definitions of violent conflict (Buhaug 2010).

Food insecurity has been found to contribute to violence, as exemplified by recent “food riots” (Johnstone and Mazo 2011, Messer 2009), but there is little empirical evidence that climate variability is an important driver of violent land-use conflicts – e.g., in the Sahel (Benjaminsen et al. 2012). In Kenya, changing rainfall patterns have the potential to increase resource scarcity as a driver of pastoral conflict (Opiyo et al. 2012). However, more conflict in the form of violent livestock theft is reported during the rainy season than during drought (Adano et al. 2012).

Similarly, conflicts over shared river systems have been associated with low-level violence, yet full-scale wars are unlikely (e.g. Bernauer and Siegfried 2012, Brochmann and Hensel 2009). Instead, an increase in international water agreements has been observed (de Stefano et al. 2012).

Finally, some studies suggest that natural disasters related to extreme weather conditions substantially increase the risk of intrastate conflict (Nel and Righarts 2008). In contrast, Bergholt and Lujala Bergholt (2012) find no increased likelihood of armed civil conflict due to weather related disasters, and Slettebak (2012) observes that, in crisis, cooperation frequently prevails.

New research is on the way as new databases on non state conflicts, low-level violence, social instability events, and geo-referenced spatiotemporal patterns become available (Busby et al. 2012, Nardulli and Leetaru 2012, Raleigh and Kniveton 2012 and Appendix A). In addition to data needs, it is important to account for complexities in the relation between climate change and conflict. There are multiple pathways and feedbacks between the climate system, natural resources, human security, and societal stability (Figure 2.1).

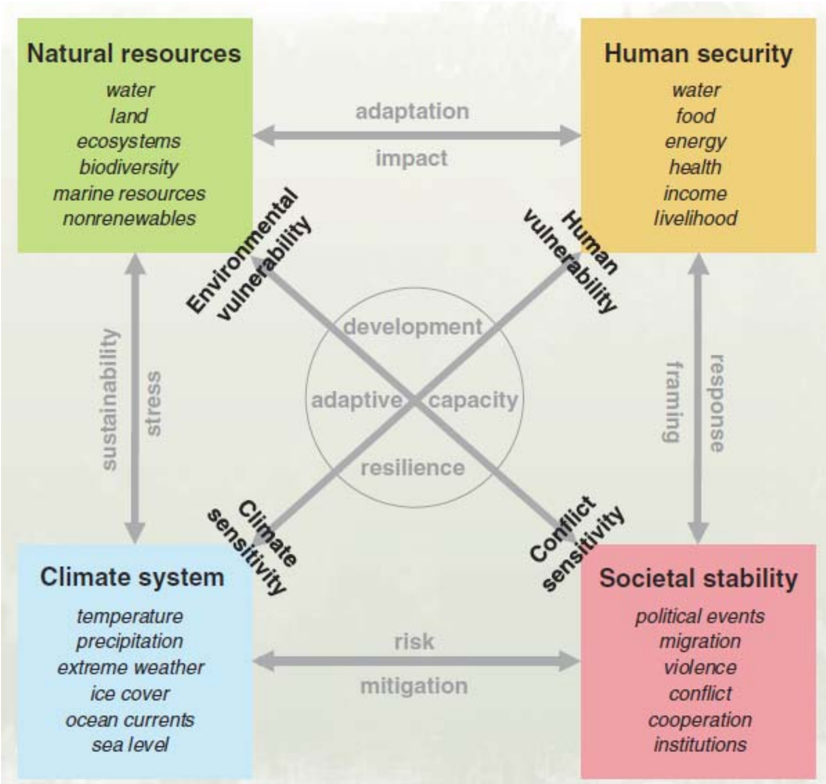

Figure 2.1 Analytical framework of linkages between the climate system, natural resources, human security, and societal stability (based on Scheffran et al. 2012b)

Since the 1990s, there has been an extensive scientific debate on how the scarcity of natural resources affects violence and armed conflict (Bächler 1999, Homer-Dixon 1994). More recently, conflict studies pay attention to the vulnerability of natural and social systems to climate impacts (Scheffran and Battaglini 2011). Vulnerability can be broken down into three factors: (i) exposure to climate change, (ii) sensitivity to climate change, and (iii) adaptive capacity (IPCC 2007a). The last two can be affected by conflict. Many of the world's poorest people are exposed to various risks to life, health, and well-being. If climate change adds to these risks, it can increase humanitarian crises and aggravate existing conflicts without directly causing them.

The question is whether human development, resilience, and adaptive capacity can compensate for increasing exposure and sensitivity to climate change. In previous decades, humanitarian aid, development assistance, and wealth per capita have increased (OECD 2012), which has contributed to a reduction of global poverty as a possible driver of conflict. International efforts to prevent and manage conflicts have also been strengthened, and the number of armed conflicts has declined since the end of the Cold War (Themnér and Wallensteen 2011). In recent years, however, this trend slowed down or is being reversed. While the number of democratic states has grown over the past half-century, the number of fragile states with weak institutions has also increased (Marshall and Jaggers 2010).

If the debate on the securitization of climate change provokes military responses and other extraordinary measures, this could reinforce the likelihood of violent conflict. Main aspects of security concern include interventions in fragile states, the securing of borders (e.g., against disaster refugees), and access to resources (e.g., in the Mediterranean or Arctic region, see Brzoska 2012). Other responses to climate change may also become causes of conflict, including bioenergy (as producers compete for land and food related resources), nuclear power (which can lead to nuclear weapons proliferation), or geoengineering (through disagreements between states). Thus, there is a need for conflict-sensitive mitigation and adaptation strategies that contain conflict and contribute to cooperation via effective institutional frameworks, conflict management, and governance mechanisms.

Research Challenges

The balance between political and social factors and climate change could shift when the global temperature reaches levels that have been unprecedented in human history. There is reason to believe that such a change might overwhelm adaptive capacities and response mechanisms of both social and natural systems and thus lead to “tipping points” toward societal instability and an increased likelihood of violent conflict (WBGU 2008).

Although some fundamental issues have been raised in previous research, numerous interdisciplinary questions still need to be investigated to understand the feedback loops involved (Table 2.1). Models of the various linkages can build on a rich set of tools from complexity science, multi-agent systems, social-network analysis, and conflict assessment to extend previous data and experiences into future scenarios that cover different social, economic, and political contexts (Scheffran et al. 2012b). Research across scientific disciplines will be needed to identify opportunities and coherent strategies to address societal challenges related to climate change.

Table 2.1 List of core research questions structured by the relations between causes and effects of the human-environment interaction (the authors)

	Effect			
Cause	**Climate change**	**Natural resources**	**Human security**	**Societal stability**
Climate change	Which climate feedbacks enhance or dampen the speed of climate change? Where are thresholds and tipping points?	How are water, land, and biodiversity affected by climate change, e.g., by drought, soil erosion, or flooding?	How do extreme weather and climate variability affect human livelihoods, health, income, and assets?	How does extreme weather affect social conflicts? How can research scenarios of impacts inform politics?
Natural resources	How do losses of natural resources affect climate change, e.g., through deforestation, ocean uptake, or desertification?	Are there relevant natural adaptation or substitution processes for the loss of natural resources?	How does resource availability affect human security? How to increase resilience and adaptive capacity?	Is conflict triggered by resource abundance or degradation? Does societal stability depend on natural resources?
Human security	Under which conditions do gains or losses of human security drive climate change and mitigation?	How does human (in-)security affect use of natural resources? Does a decline in production reduce resource inputs?	Do elements of human (in-)security reinforce each other? Will security risks spread to neighbor regions?	Does human insecurity drive cooperation or conflict? Will human responses lead to social transformation?
Societal stability	How do social unrest and violent conflict affect carbon emissions? Will social stability lead to climate mitigation?	How does societal stability affect resource exploitation? Can cooperation protect resource stocks?	How do conflict, societal instability, and cooperation affect human security and vulnerability?	Under which conditions do societies (de-) stabilize themselves or solve conflicts? What is the role of institutions?

3. Theories and Models of Climate-Security Interaction: Framework and Application to a Climate Hot Spot in North Africa[8]

Abstract

Various studies suggest that climate change aggravates environmental degradation and resource scarcity, which may contribute to violent conflict in a number of ways, including resource captures, mass migrations, and conflicts over the distribution of risks and costs between countries. However, it is also possible that addressing the problems and risks might lead to more cooperation instead. This paper analyzes climate-induced human insecurity and conflicts within a conceptual framework of conflict and cooperation, assessing the link between environmental factors, human security and societal instability. To enhance the ability to understand and deal with future threats to human security posed by climate change, a macro-level analysis is conducted for the Nile river basin that could turn into a climate hot spot. The approach combines data analysis, modeling and decision assessment in an interactive laboratory for integrated climate security assessment. The aim is to provide a deeper understanding of the climate-society links and the potential for destabilizing cascading effects and tipping points. The analysis of impacts and responses provides a basis for developing and testing strategies and policies for adaptation, stabilization, cooperation and conflict resolution in the regions of concern.

3.1 Introduction

In its Fourth Assessment Report (AR4), the *Intergovernmental Panel on Climate Change* (IPCC) addresses serious risks that could undermine the living conditions of

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[8] This chapter has been published in the peer reviewed publication Scheffran, Jürgen, Link, Peter Michael, Schilling, Janpeter, 2012. Theories and Models of the Climate-Security Interaction: Framework and Application to a Climate Hot Spot in North Africa In: Scheffran, J., Brzoska, M., Brauch, H.G., Link, Peter Michael, Schilling, J. (Eds.), Climate Change, Human Security and Violent Conflict. Springer, Berlin, pp. 91-131. As the lead author, Jürgen Scheffran is responsible for the majority of the chapter's content. Janpeter Schilling has contributed about 20%. His main contributions were the analysis and compilation of the empirical studies on climate change and conflicts, and the literature review for the Nile conflict case study. The modelling of the Nile conflict was conducted by Michael Link.

people all over the world (IPCC 2007a). Impacts on food and water availability, flood and storm disasters, and large-scale events such as loss of the monsoon, breakdown of the thermohaline circulation, polar ice melting, or sea level rise could affect a considerable fraction of the global population. After publication of this report a number of studies suggested that the struggle for food and water, the impact of natural disasters, and large-scale migration could pose security risks that would destabilize social systems and aggravate existing conflicts. These concerns inspired a debate on the securitization of climate change (Brauch 2009b, Wæver 1995). The IPCC reports did not focus on the links between climate change, security, and conflict (IPCC 2007a, Nordås and Gleditsch 2009), although statements by IPCC Chair Rajendra Pachauri upon acceptance of the Nobel Peace Prize suggest such a linkage. In its planned fifth assessment report, the IPCC will include a chapter on the human security dimensions of climate change. The security implications of climate change are very complex and cover highly uncertain future developments, precluding simple predictions. While statistical analysis of a large number of cases can provide guidance about possible linkages, additional theoretical efforts are required to reconstruct the causal relationships and pathways connecting climate change and conflict in individual case study regions. The great unknown is how human beings and societies will respond to the expected consequences of climate change. Will the social stress they are likely to experience lead to more security risks and conflicts or rather contribute to the solution of the problems and strengthen cooperation, improving societal stability? A systematic and integrated assessment of the climate-security link is still lacking. There is a need to design interdisciplinary and theoretical approaches to improve the understanding of how actors adapt to climate change and whether potential security implications can be avoided. Besides lack of theory, there is very little modeling of the link between climate change and conflict, contrasting with the extensive modeling and simulation carried out by the climate research community. To bridge this gap, theoretical approaches and modeling tools are presented here to analyze the complex relationships and possibly provide guideposts for future research. An integrated assessment framework is introduced to analyze the causal chain between climate change, natural resources, human security, and societal stability. The aim is to provide a deeper understanding of the links between climate and security and their potential to induce destabilizing effects, affect tipping points, and trigger conflicts.

Within this framework the authors explore the key linkages and sensitivities between these variables and systems as well as possible pathways of interaction, with reference to theories and models that are applicable and relevant in this context, without aiming for an extensive survey of the modeling literature. While the natural science aspects only receive minor attention, there is a particular focus on the role of human responses, actions, and interactions affecting natural and social systems. The impacts of and responses to climate-induced stimuli are evaluated in the context of an adaptive agent model of action and interaction. Conceptual issues of vulnerability, risk, security, stability, and adaptation are touched upon only as far as necessary (for a more detailed discussion of terms see Scheffran and Battaglini 2011). The macro-level global analysis is exemplified and specified by a micro-level analysis of a climate hot spot in North Africa for the water conflict in the Nile river basin.

3.2 Empirical Assessments and Pathways of Climate Conflicts

A number of studies express concern that climate change could overwhelm the adaptive capacities of societies and contribute to their destabilization, possibly leading to security risks and the use of violence along various pathways, including resource capture, mass migrations, and armed conflicts between countries (for an overview see Brauch 2006b, Brzoska 2009, Buhaug et al. 2010, Carius et al. 2008, Maas and Tänzler 2009, Scheffran and Battaglini 2011).

In addition to these more policy-oriented studies and statements, there is a significant scientific debate on the climate-conflict link which highlights some of the critical research issues (Barnett 2003, Barnett and Adger 2007, Dabelko 2009, Nordås and Gleditsch 2007, Raleigh and Urdal 2007). Several quantitative studies and databases[9] provide empirical material together with statistical analysis to test hypotheses about the relations between climatic variables (temperature,

[9] These include but are not limited to: Peace Research Institute Oslo (PRIO) data on armed conflict; Uppsala Conflict Data Programme Non-State Conflict Dataset; Correlates of War Project at the University of Illinois; KOSIMO database of the Heidelberg Institute for International Conflict Research; Inventory of Conflict & Environment (ICE); American University of Washington; Armed Conflict Location and Event Data (ACLED). Sources on disasters are the Emergency Disasters Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters, Louvain (CRED), WHO (World Health Organization) Collaborating Centre for Research on the Epidemiology of Disasters. The Cline Center for Democracy at the University of Illinois operates an event database on societal instability indicators (Nardulli and Leetaru 2012).

precipitation) and conflict related variables (number of armed conflicts and casualties). Empirical studies do not provide a clear picture yet, which may be due to lack of data or to the fact that climate change is an issue of the future. Some indications can be acquired by looking at historical cases which suggest that the rise and fall of civilizations was affected by a changing climate (Fagan 2004). Recent studies have found significant statistical correlations between a changing average global temperature and the frequency of wars, e.g. during the Little Ice Age (Tol and Wagner 2010, Zhang et al. 2007b). However, Buhaug et al. (2008) argue that a simple relationship between temperature change and the number of armed conflicts cannot be justified over the last two decades because the number of such conflicts has declined after the end of the Cold War, while temperature has increased (Figure 3.1).

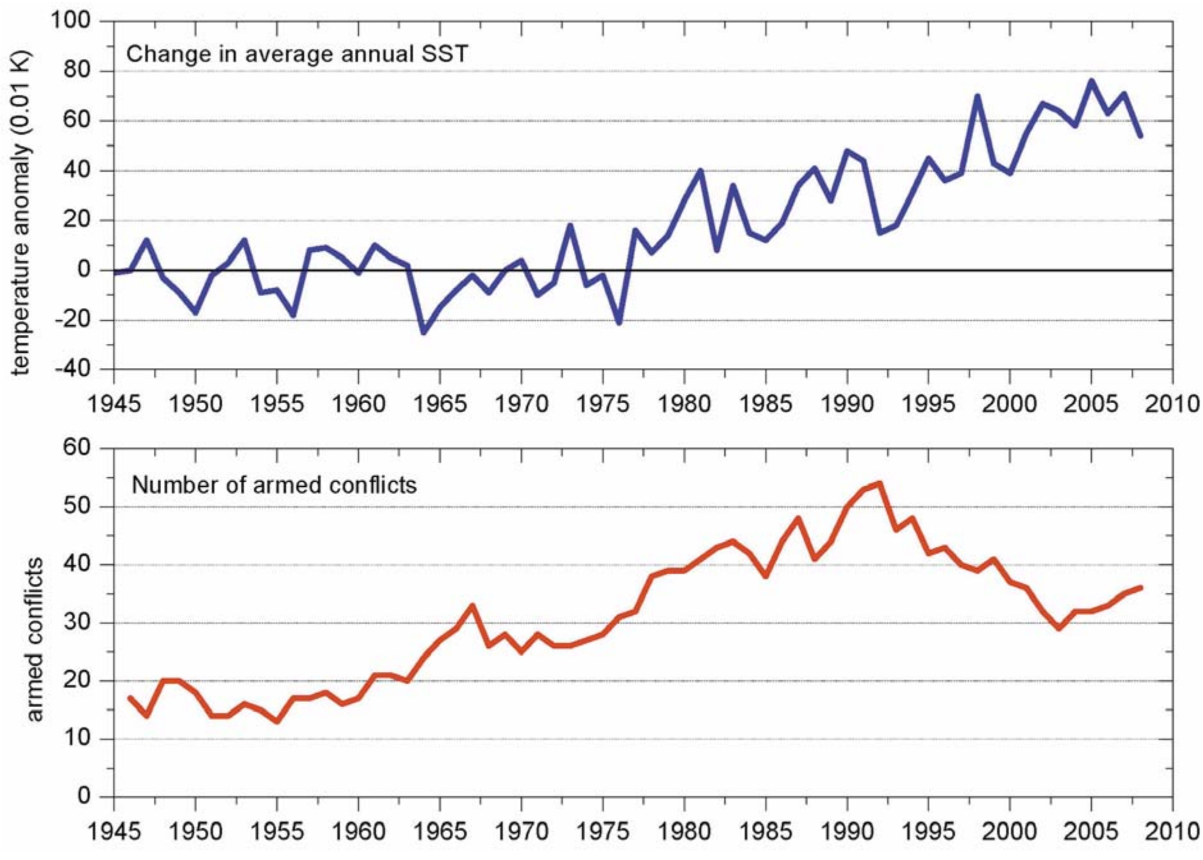

Figure 3.1 Global anomalies in sea surface temperature (SST) with respect to the period 1951-1980 (above) and the number of armed conflicts (below) for the time period 1945-2008 (drafted by the authors based on data by NOAA (2009) above and PRIO (2009b) below)

One possible explanation is that climate change so far has not directly affected large-scale conflicts such as war and will more likely cause small-scale events of societal instability and low-level conflicts. The latter have tended to increase in recent decades, as suggested by the Heidelberg Conflict Barometer which distinguishes five conflict intensities, from latent conflict to war (Heidelberg Institute for International Conflict Research 2010). Gathering data about smallscale events such as protests, riots, low-level violence, crime, and police action is an important task of ongoing research (Nardulli and Leetaru 2012). A challenge for future research is to expand and combine databases on various environmental, conflict, and socio-economic variables in order to identify security syndromes in regional climate hot spots. Additional information could be acquired through news services, local surveys, interviews, focus groups, and stakeholder dialogues in order to enhance the understanding of local perceptions and human response patterns.

Until more data are available, it is promising to look at regional case studies of environmental conflicts, which are important for exploring the relationships in detail (see WBGU 2008). During the 1990s, several research groups have examined how the scarcity of natural resources such as minerals, water, energy, fish, and land affects violence and armed struggle. These include the Toronto Project on Environment, Population and Security (Homer-Dixon 1991, 1994), the Swiss Environment and Conflict Project (ENCOP; Bächler 1999), the International Peace Research Institute in Oslo (Gleditsch 1997), the Woodrow Wilson Center’s Environmental Change and Security Project (Dabelko and Dabelko 1995), Ecologic (Carius and Lietzmann 1999) and adelphi research in Berlin (Carius et al. 2008). The review of 73 empirically recorded environmental conflicts that occurred between 1980 and 2005 shows that these had a regional scope and did not present a serious threat to international security (Carius et al. 2006).

Using a multivariate analysis, Hauge and Ellingsen (1998:299) suggested that “factors like deforestation, land degradation, and scarce supply of freshwater, alone and in combination with high population density, increase the risk of domestic armed conflict, especially low-level conflict.” Others have challenged this result, and Theisen (2008) could not even replicate Hauge and Ellingsen’s published results with the data posted. According to Gleditsch (1998), the meaning of ‘environmental conflict’ is often not clear, and important variables are neglected. Some models are virtually untestable; the causality of the relationship is sometimes reversed; foreign and domestic conflict is not distinguished. Barnett (2000) argues that the environmental conflict hypothesis is more theoretically than empirically driven. Other studies point out that it is not the scarcity of natural resources that is driving conflict but rather their abundance (Collier 2000, de Soysa 2002b, Peluso and Watts 2001), suggesting that the influence on conflict depends on the type of resource. In some cases the income from the capture of valuable resources (e.g. diamonds) can be used to buy arms or pay soldiers, which would further fuel existing conflicts. This may be less the case for vital renewable resources that are affected by climate change, which rather makes resource scarcity a factor contributing to conflict.

To provide a more detailed background about the range of empirical results concerning the statistical correlations between climate change and conflict, the table in Appendix B highlights some of the results from previous research since 2000, without being comprehensive or exhaustive. The statements suggest that there is a wide range of possible pathways between environmental changes and conflict-relevant trends, making it difficult to deduce general conclusions. The integration of the potential complex pathways provides a blueprint for further climate-security analysis and points to possible cause-effect relationships as well as to relevant factors for avoiding risks and conflicts (Figure 3.2).[10] Effects of anthropogenic climate change interact with individual human needs to have an impact on the underlying social dynamics. Depending on how welfare is affected and what the prevalent socio-economic boundary conditions look like in the region, such changes can have a lasting consequence for the given social structures. If the societal implications are negative, the risk of conflict may increase as a function of the motivation and opportunity for conflict. Any rise in the risk of armed conflict will then reflect back on the social dynamics and socio-economic boundary conditions as well as on individual human needs.

Due to non linear effects, an increase in average mean temperature above a certain threshold (such as 2 °C) may result in disproportionately strong impacts, such as a reduction of water availability and agricultural output in climate hot spots of Africa, Central and South Asia, or Central and South America (Hare 2006, Schellnhuber et al. 2006). Food insecurity in one country may further increase competition for resources and drive parts of the population to migrate into neighboring countries. It is important to understand how levels of security and risks of potential conflict are affected by rising temperatures in a particular region, and how human and societal

[10] The arrows represent an impact between two factors, without indicating its sign or strength. Some of these linkages are subject to empirical research, others may be hard to test, either because the variables are not clearly measurable or because there are several intervening factors. The main purpose of this complex framework is to show the limits of simple statements and to identify crucial factors that could stabilize possible roads to conflict.

responses influence that development. To further study these relations, the possible pathways need to be embedded into an integrated framework of climate-society interaction, which is described in detail in the following section.

3.3 An Integrated Assessment Framework of Climate-Society Interaction

Given the discussion above, it is important to treat the security implications of climate change not as isolated phenomena but in their societal context. As Figure 3.2 indicates, there are various possible pathways between climate change and conflict that are influenced by a number of contextual conditions, intermediate variables, and intervening responses.

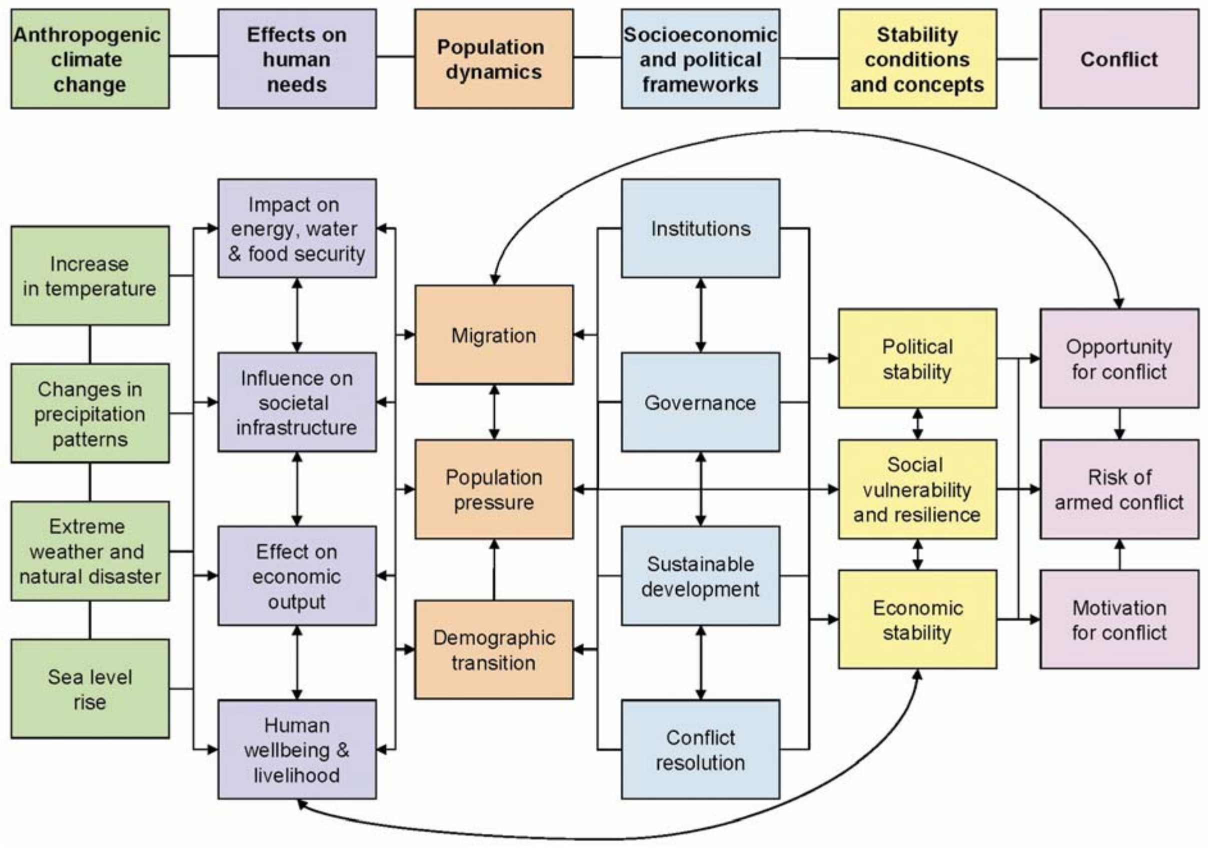

Figure 3.2 Possible pathways from climate change to conflict (the authors' own representation, modified and expanded from Buhaug et al. (2008))

Furthermore, the societal and political levels are not only affected by climate change, but they affect it in turn, indicating that circular feedback is relevant. This serves as a motivation to develop an integrated perspective that takes the complexity of the issues into consideration from the start. While the authors do not expect to come to a conclusion with regard to the methodological challenges in this chapter, they look to contribute to addressing the challenge in a systematic manner and indicating pathways for research that could possibly frame the future debate. Rather than searching for empirical links like needles in a haystack, it is essential to make it clear that empirical investigations into the key linkages should consider the theoretical context. If, as a hypothetical example, climate change triggered violent conflict in some cases and cooperation in other cases, then on average climate change might not have any measurable impact on conflict. In attempting to identify the conditions under which conflict is triggered or not, statistical analysis of previous cases can provide some clues, but it reaches its limits when it comes to complex, uncertain, and long-term future processes. Due to the circular relationships between the variables, each pair of variables could be connected through multiple pathways, and this means particular care must be taken when selecting dependent and independent variables. Developing a conceptual framework to analyze these pathways could thus be of added value for empirical investigations. Within this context, the analysis needs to be embedded into an integrated assessment framework of climate-society interaction that represents the causal links between climate change, natural resources, and environmental stress, human values and needs, and the societal consequences and instabilities (Figure 3.3):

1. Changes in the climate system such as increases in greenhouse gas concentration, temperature, and altered precipitation patterns affect environmental systems and natural resources (e.g. soil, water, ecosystems, forests, biodiversity) through a sequence of complex interactions.
2. Changes in natural resources can have adverse impacts on human values and capabilities, which may provoke human responses that can affect social systems.
3. Depending on the degree of vulnerability, socioeconomic stress increases as a result of water and food insecurity, health problems, migration, economic degradation, the weakening of institutions, diminishing economic growth, and eroding societies.
4. Interdependencies between these factors may lead to societal instability that can manifest itself in violent forms such as riots, insurgencies, urban violence, or armed conflict.

5. A feedback loop allows human beings and societies to adapt to the changing situation and mitigate climate stress through strategies, institutions, and governance mechanisms that may apply technology or human and social capital to adjust the economy and the energy system to the altered environmental conditions.

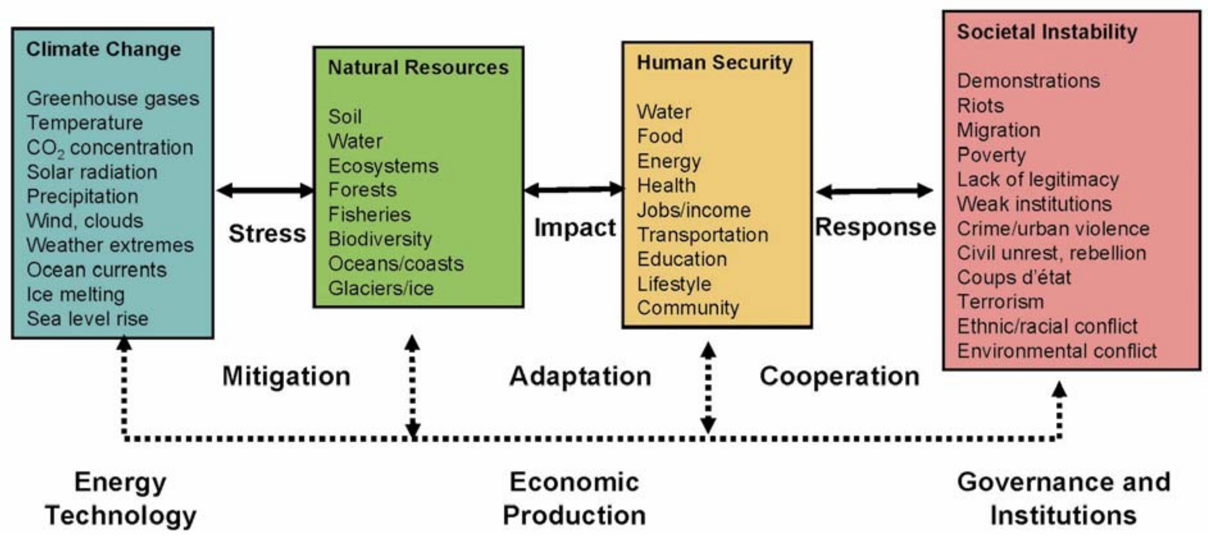

Figure 3.3 Causal relationships between climate change, natural resources, human security, and societal impacts (adapted from Scheffran (2011))

The significance of the impacts of climate change on society and security can be deduced from the links between the variables and how events spread along the causal chain, which is a function of the sensitivities between variables. Examples of events could be an increase or a drop in temperature and/or precipitation, the loss of species, the occurrence of disasters, an action by human beings, or collective action by a group of people, such as riots or war.[11]

According to the IPCC (2007a:881), sensitivity in the context of climate change is the "degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect

[11] Events are represented by changes Δx in a system variable x, which may induce a change Δy of another variable y, expressed by a functional relationship between both variables $\Delta y = y_x \Delta x$. Here y_x is the sensitivity of changes in y with regard to changes in x (mutual impact), which can either represent a positive coupling ($y_x > 0$) or a negative one ($y_x < 0$). Similarly, a change in x can affect its own dynamics (self-impact x_x) which determines
whether an increase in variable x leads to further growth ($x_x > 0$: exponential growth), or to a decline ($x_x < 0$: exponential decay). For a functional relationship between the variables and sufficiently small variable changes, sensitivity can be approximated by first-order partial derivatives of the respective variables; for larger variations higher orders need to be included. In general, the sensitivities are not constant but may depend on the system variables, including space and time.

(e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise). A prominent example is climate sensitivity, i.e. the temperature change induced by a doubling of CO2 concentration in the atmosphere. While climate sensitivity is essential for determining the impact of climate change, its measurement is associated with high uncertainty, despite considerable research into the underlying natural processes. This indicates that the nature of the sensitivities is not deterministic but probabilistic, and this is even more the case in relationships involving human responses.

Since several intermediate variables are involved, estimates are needed for each of the individual sensitivities that in combination yield the overall sensitivity. An example is the interaction between variables in the atmosphere and biosphere systems (Figure 3.4).[12]

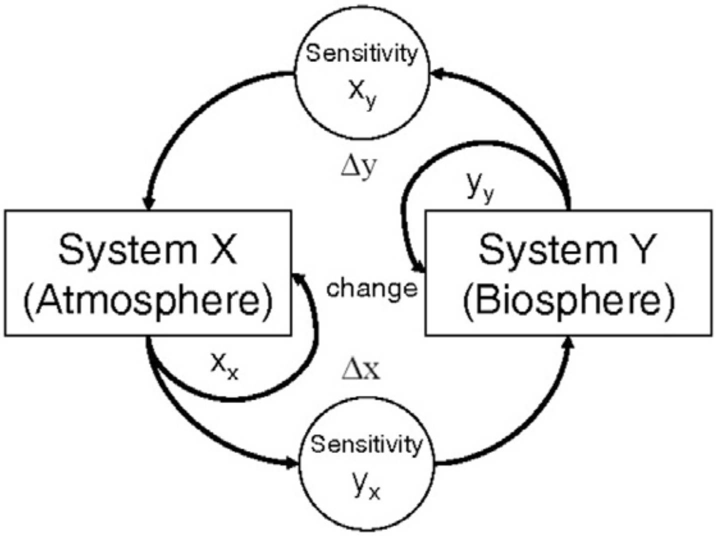

Figure 3.4 System-system interaction, exemplified by atmosphere and biosphere systems (modified from Scheffran (2011))

Many more of these linkages are possible. Estimates of the sign and magnitude of these relationships can be presented as impact graphs that serve as an analytical framework for describing the network of connections between the variables and the associated spread of events. The possible causal chain from climate stress to societal instability can be constructed through a series of links in which the couplings between the variables are represented by their sensitivities (Figure 3.5). Changes in the *climate system (C)* affect *natural resources (N)*. Environmental changes will

[12] Here x_y measures the sensitivity of carbon Δx extracted from the atmosphere to build biomass Δy in trees. Accordingly, y_x could be the impact of anthropogenic carbon emissions Δx on forest growth Δy through the effect of global warming.

influence *human security (H)* and can ultimately trigger impacts and events that affect the *stability of society (S)* (for a specification of these systems and impacts see the following sections). Since each of these systems is characterized by a vector of variables, the links between the variables of each system can be represented by a sensitivity matrix (X_Y) that indicates how sensitive a variable in vector *X* is with regard to a variable change in vector *Y*.[13] Statistical multivariate analysis of data makes it possible to estimate the sensitivities based on data, although in reality some of the sensitivities may be highly uncertain and/or difficult to measure.

Key sensitivities are the stress induced in natural resources by climate change (N_C), the impact of environmental change on human security (H_N), and the societal consequences of changes in human living conditions (S_H).

The coupling between climate stress and societal instability (S_C) captures the direct connection between climate change and societal stability. Other linkages are also relevant here, such as the coupling between human security and climate change *HC*, between societal and environmental change S_N, and the reverse couplings (impacts on climate change) C_N, C_S, C_H, and so on. Since there are dynamics within each of these systems as well, there are also internal couplings of variables denoted by matrices C_C, N_N, H_H, and S_S (Figure 3.5).

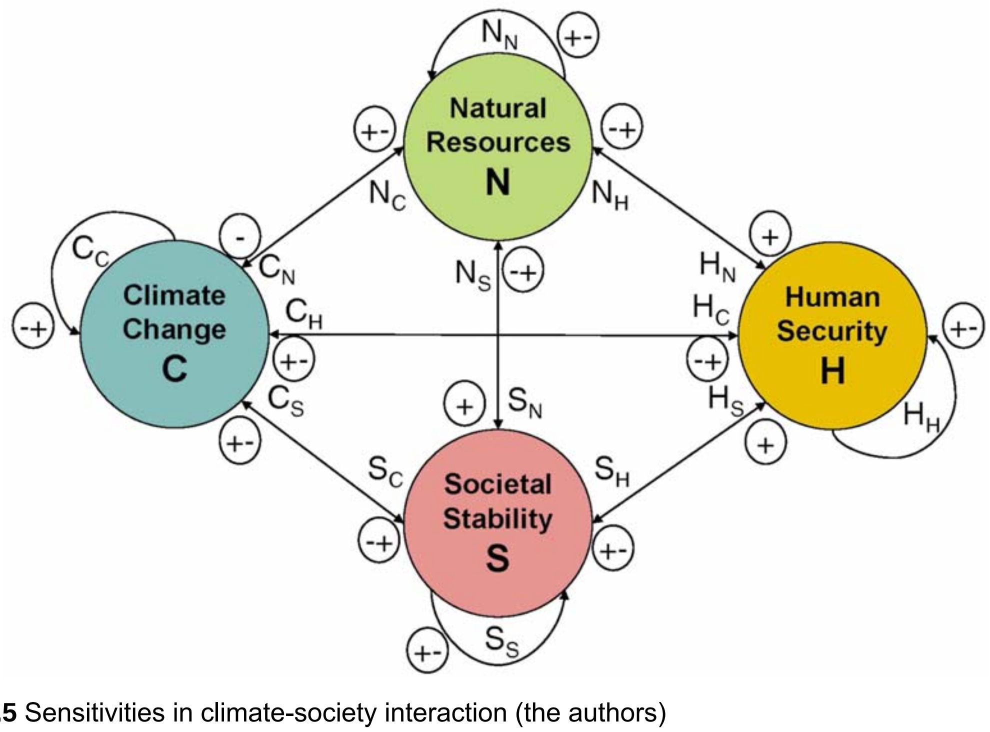

Figure 3.5 Sensitivities in climate-society interaction (the authors)

[13] Small letters (x_y) represent sensitivities of variables, capital letters (X_Y) represent sensitivities of systems of variables or vectors.

In addition to the direct links, there are indirect links between each pair of systems through other systems, e.g. the impact of climate change on society through environmental and human impacts. The overall impact of climate stress on societal stability can be represented by the various pathways through which climate related events can spread, including those shown in Figure 3.2.[14] The question is how societies respond to a loss of stability induced by climate change. A more stable society is better equipped to mitigate climate change, but a reduction of stability due to climate change would send the system into a feedback loop, aggravating the problem. Since C, N, H, and S represent large systems that comprise sets of variables, the interaction becomes more complex if all links between the individual variables are taken into consideration.

As mentioned above, key climatic variables are greenhouse gas emissions and concentrations, global temperature, precipitation, sea level, etc. Natural resources are water, food, or biodiversity. Human security rests on a wide range of human values and capabilities, and societal stability relies on a number of indicators regarding the type of destabilizing events such as riots, violent attacks, or wars (see Figure 3.3 and the discussion in the following sections). Accordingly, there is a vast range of possible combinations and thus pathways. In addition, the internal dynamics within each of the systems have to be considered as well. The same holds for the relations between the different compartments, e.g. between temperature and precipitation in the climate system, between water and food as natural resources, the relationship between different human values, or societal interaction patterns. The whole setup is not a deterministic system because human beings as well as societies can respond in different ways that are shaped by social behavior, policies, and institutions, all of which are affected by uncertainties. A discussion of the sensitivities in Figure 3.5 is given in Table 3.1, based on qualitative considerations.

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[14] For instance, a temperature increase $\Delta T > 0$ can lead to a loss of natural resources $\Delta N = NT\,\Delta T < 0$ if sensitivity $N_T < 0$ is negative. This resource loss can have a negative impact on human security $\Delta H = H_N\,\Delta N < 0$, provided natural resources are positively related to human security ($H_N > 0$). If human beings respond to this loss in a way that undermines the values of other social actors, it can reduce the stability of society $\Delta S = S_H\,\Delta H < 0$, assuming that stability is positively related to human security. It may, however, also lead to human responses that foster collaboration between people to compensate for the loss, in which case societal stability may rather be increased $S_H > 0$. The combined effect of temperature change ΔT on societal stability along the full pathway $C \rightarrow N \rightarrow H \rightarrow S$ would be $\Delta S = S_H\,H_N\,N_T\,\Delta T$, which is the product of the sensitivities along this pathway. It is also possible that societal stability is directly affected by temperature change via $C \rightarrow S$ (e.g. by a disaster or heatwave), and indirectly by the pathway $T \rightarrow H \rightarrow S$ and $\Delta S = S_H\,H_T\,\Delta T$. Finally, temperature change could directly affect societal stability $T \rightarrow S$ if a severe disaster destroys the infrastructure of society, thus the change along this pathway is $S = S_T\,\Delta T$ (Figure 5.5).

Table 3.1 Typical sensitivities in relationships between causes (vertical) and effects (horizontal) of climate-society interaction (the authors)

Cause →Effect	**Climate change**	**Natural resources**	**Human security**	**Societal stability**
Climate change	[C_C] Despite a natural removal of carbon from the atmosphere that dampens climate change (-), increased carbon emissions can trigger rapid climate change through positive feedbacks and the crossing of tipping points (+).	[N_C] Although in some areas biomass may grow better with higher atmospheric carbon concentrations or temperature (+), climate change reduces the carrying capacity and productivity of many natural resources (-).	[H_C] Changing climate negatively affects human wellbeing and security, e.g. through disasters and adverse climatic conditions (-); in some cases benefits are possible (+).	[S_C] Natural disasters and large-scale climate change can weaken societal structures (-) or trigger transformation processes that stabilize society (+).
Natural resources	[C_N] There are some feedback mechanisms from natural resources that aggravate climate change, e.g. depletion of fossil fuels or loss of biomass releasing more carbon (-).	[N_N] Many natural resources grow exponentially (+) or logistically when reaching limits (still +) but may also break down at certain thresholds (-).	[H_N] Since human needs depend on natural resources (+), their decline may lead to a loss of human security.	[S_N] Since various socioeconomic structures depend on the exploitation of natural resources (+), their decline affects these structures.
Human security	[C_H] Decline in human security may lead to less production, consumption, and emissions (+) or provoke responses such as increased deforestation or use of fossil fuels that aggravates climate change (-).	[N_H] An increase in human security can lead to an expansion of the exploitation of natural resources (+) or to its decline (-).	[H_H] Depending on individual responses, a loss in human security can lead to a downward spiral (+) or to counteractions that improve the situation (-).	[S_H] Threats to human security can provoke human responses that undermine societal stability (+); effective strategies would stabilize societies (-), e.g. through cooperation.
Societal stability	[C_S] Wealthier and more stable societies may either increase emissions (+) or reduce emissions (-).	[N_S] Social development can lead to an expanded exploitation of natural resources (+) or to sustainable resource use (-).	[H_S] More stable societies are better suited to satisfy human needs (+).	[S_S] Within a particular stability range societies tend to stabilize themselves (-); outside of this range destabilizing tendencies may prevail (+).

In general, the sign is not predetermined and depends on various conditions and variables. In the following sections, the sensitivities and linkages of climate change to each of the other three systems (natural resources, human security, and societal stability) are discussed in greater detail. Possible tools for modeling their interactions are also considered.[15]

3.4 Climate Stress on Natural Resources and Resilience of Ecosystems

In a narrow sense, the climate system comprises the earth's atmosphere, in a wider sense it includes the natural processes to which it is connected, including land and oceans, the biosphere, the cryosphere, and the pedosphere. Natural resources are based on natural processes and may be renewable (e.g. sunlight, water, trees, fisheries) or non renewable, i.e. they do not re-grow or come back in a relevant period of time (e.g. fossil fuels or minerals).

The interaction between climate change and natural resources is determined by the laws of nature and can be thus represented by a set of system variables that are mutually interconnected. The degree of environmental change is indicated by the sensitivity of environmental variables, organisms, and ecosystems to the stress caused by climate change events, such as global and regional temperature change; a drop in precipitation; the increase in floods and storms; or a rise in sea level. The rise of global temperature and its variability alters many natural processes and cycles, including precipitation patterns, ice formation, and biological systems and their distribution.

Climate change has a multitude of potential impacts on the natural environment which are closely interrelated. For instance, reduced water availability affects ecosystems and soil conditions; sea level rise threatens many coastal regions. Extreme weather events, such as hurricanes, flooding, and heatwaves, are expected to increase in frequency and strength and can be highly destructive where they hit. Largescale events such as the loss of the monsoon, the melting of the Greenland or West Antarctic ice sheets or the shutdown of thermohaline circulation can trigger irreversible 'tipping elements' in the climate system (Lenton et al. 2008). Where natural resources are at a critical stage, global warming may degrade the environment as a source or as a sink of natural resources.

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[15] Since the purpose is not to provide a literature review but to develop an integrated model framework expanding previous work by the authors, we seek to minimize rather than maximize the references to other publications. We refer here to some publications that cover several of the models used in this context: Sprinz and Wolinsky-Nahmias (2004); Billari et al. (2006); Scheffran (2006b); Kropp and Scheffran (2007).

Many natural systems are vulnerable to climate change and have limited adaptive capacity; examples are glaciers, coral reefs, mangroves, and wetlands, or arctic and mountainous ecosystems. Some of the ecosystems may experience irreversible change and lose biodiversity; others are more robust against external influences. Resilient ecosystems are able to adapt and preserve their existence through feedback cycles that maintain stability. A related concept is viability, which in this context is the ability of an organism or ecosystem to live, grow, and develop. Viability is possible within the limits of environmental conditions, outside which viability becomes negative, threatening the existence of living systems (Figure 3.6). If the feedback cycles are disturbed as a result of climate change, and the tolerable domain of viability is left, catastrophic changes may occur, leading to the loss of valuable functions of the ecosystem. The stability and resilience of the ecosystem indicates whether these functions can be preserved against likely disturbances. Figure 3.6 shows that a change in environmental factor *x* has quite different impacts on the viability *V* of a natural resource, depending on the actual state of the environmental factor. Below the optimum, the viability increases, above the optimum viability declines.

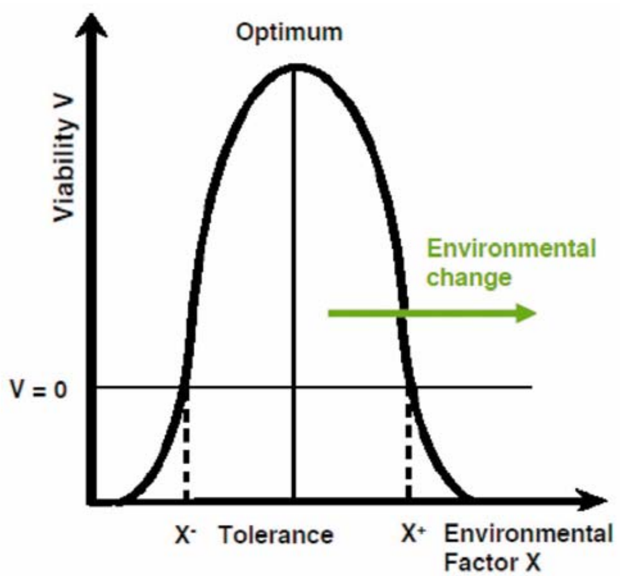

Figure 3.6 The impact of environmental change on the viability of living systems, using a stylized shape of the viability function (the authors). The bell-shaped curve represents the qualitative property that viability becomes negative outside the tolerance limits and reaches a maximum somewhere between these limits. For specific systems the shape can be less smooth

This implies a switch in sensitivity from positive to negative values at the optimum. Since natural systems are often adapted and 'optimized' to particular environmental conditions, this means that with climate change the sensitivity to temperature increase becomes negative if the level of the environmental factor exceeds the optimum.

To specify the interactions between natural systems and environmental factors, statistical methods and simulation models are the primary means of understanding the long-term behavior of the climate and other natural systems. Computer simulations and dynamic systems theory study the evolution of climatic variables over time, as represented by differential or difference equations. These describe local changes for given initial conditions and constraints. Mathematical tools help to identify the equilibria and stability conditions of dynamic systems, as well as phenomena such as order and disorder, chaos, self-organization, and phase transitions. Stability theory deals with the methods of sustaining essential system properties and equilibria against disturbances over a given period. Examples are models of weather, climate, and water cycles, and of the growth of forests and fisheries. Dynamic competition models (such as the Lotka-Volterra model) describe interactions and potential conflicts between actors and populations, often with regard to scarce resources. Scenarios can be constructed by typical parameter choices in computer programs in order to explore possible futures in virtual experiments. This can help to identify key control variables that allow steering the dynamics in the desired direction.

Ecological growth models are used to describe the dynamics of natural resources N. Biological organisms and populations often follow an exponential growth function, or they grow logistically if the environment has a maximum carrying capacity above which the stock declines or even collapses.[16] Growth may be modified by other factors, e.g. by precipitation as a source of water flow or solar radiation as a source of energy, which may be affected by climate change. For instance, droughts due to increasing temperature could significantly reduce water supply or soil replenishment. A higher temperature may stimulate plant growth due to higher carbon concentration but at the same time could reduce the growth rate of an organism or the carrying capacity of ecosystems (with the overall result $N_C < 0$).

[16] Exponential growth of resource N is represented by dynamic equations of the form $\Delta N = g(N) = r\,N$, with growth rate r (corresponding to self-induced increase $NN > 0$ in accordance with Figure 5.5). If the environment has a maximum carrying capacity N^* for the resource, the growth function $g(N) = r\,N\,(N^*-N)$ represents logistic growth, which tends towards zero at the upper resource limit. Exceeding the natural limit can lead to the decline of the resource system ($NN < 0$).

Variables and relationships in natural systems are subject to uncertainties that preclude deterministic approaches and require statistical methods and models, including computational algorithms that rely on repeated random sampling (Monte Carlo methods). If there is a lack of data, qualitative modeling can help to analyze the causal structure between uncertain and fuzzy variables and complex relationships. Rather than requiring the precise measurement of variables, it is sufficient to only estimate the direction or sign of couplings between such variables. Qualitative cause-effect relationships have been applied in an integrated assessment framework (Eisenack et al. 2007). The syndrome approach is based on qualitative modeling and is suitable for classifying dynamic systems and finding solutions with similar properties. A syndrome linked to climate change is the Sahel syndrome, which is characterized by overcultivation of marginal land leading to negative effects such as soil degradation, desertification, and loss of biodiversity (WBGU 1996).

The various impacts on the climate system are ambiguous. There is the natural decay rate of greenhouse gas concentrations G in the atmosphere ($G_G < 0$), largely due to the uptake by oceans and soils. On the other hand, increased atmospheric carbon concentrations trigger a rise of temperature T ($T_G > 0$), which can intensify through positive feedbacks and the crossing of tipping points. The increasing depletion of the fossil energy stock further drives emissions. Increasing the renewable energy generation still causes some additional emissions though at a significantly lower rate than fossil fuels for the same energy unit. Various natural systems and processes such as biomass and soil formation absorb carbon ($G_N < 0$), even though they are re-emitted from biomass once plants and soil decompose. If decomposition is isolated from the atmosphere (e.g. in soils or underground) plants can be used to reduce or delay climate change. Although in some areas biomass may grow better with higher carbon or temperature ($N_G > 0$), climate change generally reduces the carrying capacity and productivity of many natural resources ($N_T < 0$). The loss of biomass then releases even more carbon.

3.5 Climate Impacts on Human Responses

3.5.1 Human Values and Needs

Climate change affects human values in multiple ways and in various dimensions. Values represent the preferences of human beings concerning certain courses of action or outcomes, including anything that is usable or valuable for humans (represented by the term ‘utility’ in economic theory). Values tend to influence attitudes and behavior. While rational actors select actions that increase or even optimize their values, there are circumstances that restrain the freedom and rationality of choice, including dependency on established action paths or the influence of the social environment that shapes individual actions. Among human values it is important to distinguish human wants from human needs essential for living a healthy life. A deficiency in fundamental needs could have severe consequences such as dysfunction or death. While wants can be infinite and insatiable, needs are few, finite, and classifiable.[17] What specifically constitutes a need is controversial, as it is subject to individual preferences and social processes. Distinguishing between human wants and needs may be essential when facing climate change. While restraints on wants are experienced as a loss by individuals and lead to dissatisfaction, impinging on fundamental needs threatens the survival of people and thus leads to more drastic responses that directly affect human security, including migration or violence (see section 3.7.2 below).

Potentially affected by climate change are systems and processes that provide human needs, including water, food and energy supplies, agriculture and land use, health, and urban life. Human values and needs can be directly affected by climate-related phenomena such as extreme events and natural disasters, or indirectly through gradually changing environmental conditions. This concerns the following major pathways of impact:

- Climate-induced stress affects human health and life, indicated by the direct sensitivity of human value to climate change (corresponding to $V_T < 0$). Life-threatening extreme weather events and disasters are expected to increase in frequency and strength. Storm and flood disasters endanger large populations, e.g. in southern Asia.
- If natural resources and ecological systems are vital for human life, their degradation through climate change undermines human wellbeing ($V_N < 0$). For instance, the melting of glaciers could jeopardize water supply for people in extensive areas, e.g. in the Andean and Himalayan regions. Through lack of clean water or food, people may become ill or die of starvation.

[17] The school of ‘Human Scale Development’ has developed a taxonomy of fundamental human needs that includes subsistence, protection, affection, understanding, participation, leisure, creation, identity, and freedom (Max-Neef et al. 1991).

- If the provision of human needs is dependent on the functioning of social systems (*V*S > 0), climate change or resource degradation influencing the stability of these systems also affects people, e.g. through a weakened economy, infrastructure, or institutions. This destabilization of society ultimately also affects wealthy people who might have the individual capability to survive but may feel threatened if everything around them falls apart. In the extreme case, climate change increases the likelihood of armed conflict costing many people's lives.

3.5.2 Vulnerability and Risks

The impacts of climate change on human values and needs are related to people's vulnerability. There is a range of different interpretations of vulnerability (Adger et al. 2009, Brauch 2005). According to Blaikie et al. (1994:275), vulnerability is the "characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard". For Ionescu et al. (2009:1) vulnerability depends on (1) the entity that is vulnerable, (2) the stimulus to which it is vulnerable, and (3) the preference criteria for evaluating the outcome of the interaction between the entity and the stimulus. Regarding climate change, the IPCC (2007a:883) defines vulnerability as the "degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes". And further, vulnerability "is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity".

The vulnerability of systems to hazards affects the risks they pose in terms of estimated losses and their associated probability (usually risk is the product of these two variables). Each of the pathways from climate change to human impacts is associated with a risk that is specific to the people affected. There is a sequence of probabilities along the causal chain: the probabilities for certain emission scenarios, atmospheric stabilization levels, global temperature change, climate change in each region, the harm for each affected system, and finally the probability for each of the possible responses. A practical approach is to focus on the essential pathways and develop aggregated risk indicators to measure how actors are potentially affected by climate related stimuli, including the loss of lives, health, money, or natural resources, ranging from moderate to catastrophic risk.

While risk assessments often deal with systemic contexts regarding technical or natural systems and claim a certain degree of objectivity, threat perceptions often refer to intentional acts that combine the capability to threaten with the motivation to threaten. Various sources have extended the threat terminology to climate change, e.g. by the term 'threat multiplier' (CNA 2007, European Commission 2008, IPI 2009). Since everyone is contributing to climate change and everyone is affected by it, we would all pose threats to ourselves. However, the asymmetry between those who predominantly cause global warming and those who are largely affected by it adds to the existing injustice between the rich and the poor.

Within the integrated assessment framework, vulnerability can be expressed as the loss of value $\Delta V = v_x \Delta x < 0$ to a climate-induced event Δx, where sensitivity v_x is the specific vulnerability connecting the event with its respective value. The same event may affect some value dimensions but not others. The risks and threats of climate change are quite heterogeneous and influenced by a number of factors and circumstances, including the timing and the geographical location of the event, the people affected, and their social environment. Risk assessments also depend on human knowledge and perception, which in reality are bound by a window of attention and its limited information. Impacts and events outside this window receive less attention than the ones inside.

3.5.3 Human Capabilities and Actions

The impacts of climate change on human beings and societies depend on their responses and actions, which are affected by their values and capabilities. Some responses could help to adapt and minimize the risks, others may cause additional problems. For instance, migration is a possible adaptive response not only to poverty and social deprivation but also to environmental hardships. What human actions can do or not do depends on the magnitude of climate change. For existential challenges affecting fundamental human needs the spectrum of effective responses is restrained, possibly increasing temptations to switch to non legal and violent acts. Alternatively, challenges could also induce people to work together to improve the chances for survival through collective action that reduces social vulnerability.

Actions can only be taken if the capability to act exists. Thus, capability is commonly understood as “the ability to execute a specified course of action” (Wikipedia 2010), which includes any means of giving people the ability to change their natural and social environment.[18] If actions are directed at producing something of value, capability is often associated with the ‘capital’ used to create goods and services (Bohle 2009, Bourdieu 1983). In economic theory, the most common dimensions of capital are natural capital (usable resources of an ecosystem), physical capital (assets made by humans for production), and financial capital (monetary wealth). Increasingly, human production factors are included, such as human capital (workers’ skills and abilities), social capital (such as social networks), political capital (instruments and institutions in political decision-making), and cultural capital (knowledge, skills, education status, and personal advantages).

In the context of human development and welfare economics, the capability approach has been developed in the 1980s by Amartya Sen (1985) and has served as a basis for the *human development index* (HDI). In distinction to other economic approaches that focus on utility, income, or access to resources, Sen emphasizes functional capabilities or substantive freedoms that are of value to people, such as the abilities to live a long life, engage in economic transactions, or participate in political activities. Deprivation of capabilities is understood as poverty which can, for instance, result from ignorance, government oppression, or lack of financial resources. A related concept is ‘livelihood’, which comprises the “capabilities, assets (including both material and social resources) and activities required for a means of living” (Carney 1998). ‘Livelihood’ deals with the opportunities people have and what they do with their resources (such as money, labor, land, crops, livestock, knowledge, and social relationships).

The risks of climate change may undermine the livelihood of people by affecting value or capability or both. To reduce climate risk, a system needs the capacity to respond and adapt to climatic stimuli and to take actions that either diminish harm or compensate for it by establishing positive values. This is in accordance with the IPCC understanding of adaptation as the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC 2007a:869). By using adaptive capability,

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[18] From now on, *C* indicates capability rather than climate change. Specification of capability and its measurement depends on the respective area of application.

the implementation of adaptation measures comes at a cost that should not exceed the magnitude of the benefits they produce.

To operationalize the vulnerability concept, indicators can be developed to measure the intensity of climate change, its value impact on various systems, and the effectiveness of capabilities and adaptation measures to reduce harm. Vulnerability would then be the ratio between relative value loss, which can be reduced by adaptation efforts, and the intensity of climate change. The relationship between stimuli, losses, and adaptive efforts depends on the response functions of the respective actors. While in some cases linear responses may be selected, in others non linear functions may be adequate, such as damped, logistic, or threshold responses, or bell-shaped curves (Scheffran 2011).

A key question is whether those affected by climate change have enough capability to counter the value losses from environmental change.[19] If such change exceeds the available capability, an actor is no longer able to prevent or fully compensate for the risks of climate change. This demonstrates that for significant environmental change actors with low capability are not able to adapt to the changing environmental conditions and associated value losses. Powerful actors may not be able to adapt either if the magnitude or speed of environmental change exceeds their capability to adjust. An alternative is to rely on systems with low specific vulnerability v_x and with efficient capabilities v_c. The implications of environmental change become even more significant and long-lasting if they not only affect value but also reduce capability itself ($\Delta C = c_x \Delta x < 0$), which in turn then affects the ability to respond. An example is the buses or hospitals in New Orleans flooded by Hurricane Katrina, factors which diminished the overall societal capability to adequately help affected people.

Environmental change not only influences human values and actions, it is also affected by it. Any human activity that applies capability requires natural resources and causes greenhouse gas emissions that change the environment. The question is how the induced direct value change from these efforts relates to the indirect value changes from the resulting environmental change and the responses taken against

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[19] Translating the qualitative assessments into formal relationships, a key question is whether those affected by climate change have enough capability C to take actions to counter value losses $\Delta V = v_x \Delta x < 0$ from environmental change Δx, where v_x is the specific vulnerability (sensitivity) of value regarding variable x. By using capability (effort) ΔC actors induce a positive value change $\Delta V' = v_c \Delta C > 0$, where v_c is the value gain per capability unit. Then capability may compensate for a value loss if net value change is at least zero ($\Delta V + \Delta V' = v_x \Delta x + v_c \Delta C = 0$), which requires a minimum compensation effort $\Delta C = \Delta x\ (v_x/v_c)$. If during action a fraction γ of the capability is lost, this equation needs to be adjusted accordingly to $\Delta C = \Delta x\ v_x/(v_c - \gamma)$.

them, considering that due to depletion and pollution of the environment the costs and risks are increasing disproportionately beyond a certain threshold. The ecological footprint concept measures human demand on the earth's ecosystems and compares human demand with the planet's ecological capacity to regenerate, given by the biologically productive land and sea area needed to regenerate consumed resources and to absorb the waste (Wackernagel and Rees 1996).

3.5.4 Rules for Decision-making and Adaptive Control

To respond to a changing climate, actors adjust their capabilities to pursue values and avoid risks, selecting among a range of action pathways according to rules, preferences, and criteria. Decision tools can help to rank and select the options. Rational decision-makers choose the most preferred or optimal option, usually maximizing utility functions. Benefit-cost analysis seeks to find climate pathways that balance high benefit, low cost, and minimal risk. In globally aggregated optimal growth models, a production function represents the flow of economic output, depending on capital, labor, and technology, assuming a global decision- maker with complete knowledge who selects an optimal time-discounted control path for the planet or for a nation. Such an approach is hard to establish for long-term climate change because there are many factors and interactions that are highly uncertain and beyond control. Furthermore, the complex socio-economic interaction among multiple actors undermines predictability (see 3.7 below).

Viability theory provides an alternative decision framework for keeping a dynamic system within viable constraints, defined by objective limits or value based judgments (Aubin and Saint-Pierre 2007). Mathematical methods can be used to confine actions to these boundaries (compare 3.4), e.g. given by a tolerable window of greenhouse gas concentrations and global temperature change (Petschel-Held et al. 1999). An important question is whether the intensity and speed of climate change exceeds the viable limits of natural and social systems, and which control mechanisms can be applied to limit carbon emissions to avoid dangerous climate change, as required by the *UN Framework Convention on Climate Change* (UNFCCC). The challenge is to identify admissible guard rails for action within which climate policy can maneuver, taking into consideration vulnerabilities and adaptive capacities as well as critical thresholds for disasters and extreme events.

While viability theory still rests on a central control mechanism, adaptive control implements actions based on locally updated information and decision rules for each actor responding to the changing state of a system. Actors decide and act on the basis of incomplete knowledge, restrained to a spatial and temporal window of information. Adaptive control adjusts to a changing environment, including the actions of other agents, to reach given targets. In climate policy, adaptive control approaches provide guidance on how to constrain and adjust greenhouse gas (GHG) emissions towards a viability domain of the climate system (e.g. a specific range of carbon concentration or global average temperature change). A possible decision rule is to invest capability in emission reductions when future projected emissions exceed a critical temperature threshold. To estimate whether current trends can be perceived as tolerable or require changing the course of action, updated information is needed about the difference between the current state and critical temperature thresholds, taking the rate of change into consideration (Scheffran 2008b). For large climate uncertainties, short-term actions may focus on low-hanging fruits, i.e. accessible actions with high benefit-cost ratios. Time plays a crucial role as there are considerable inertia and time lags in natural and social systems, in particular regarding the replacement of infrastructure and technology. Decision-makers need to consider a future time horizon and compare the consequences that occur at different times. Figure 3.7 shows the main elements of an adaptive control approach for a single actor who applies part of the available capabilities (*C*) to given action paths *(A)* to change a system environment (*X*).

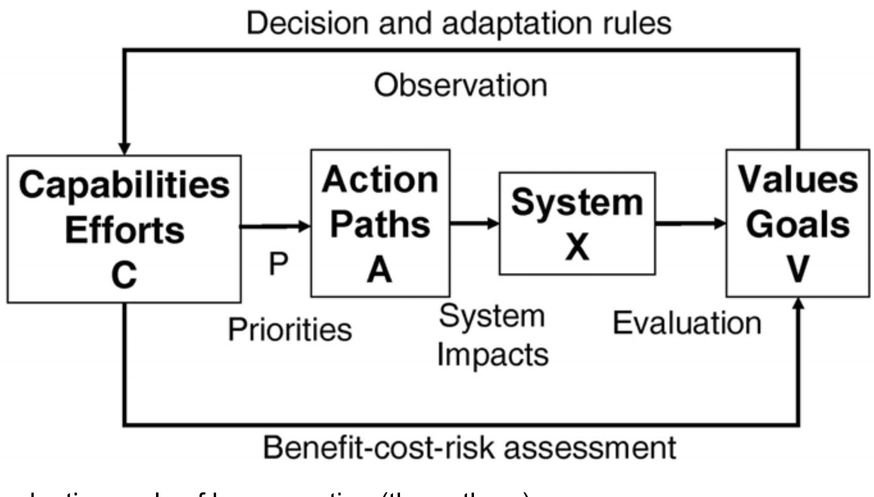

Figure 3.7 An adaptive cycle of human action (the authors)

The observed impacts are evaluated based on the actor's values and goals (*V*), which are a function of the benefits, risks, and costs of the actions. In repeated feedback and adaptation cycles, the actions are adjusted according to decision rules in response to environmental changes and their evaluation (both for the natural and the social environment).[20]

The actions taken by one actor as part of the adaptive dynamics affect the natural and social environment and provoke responses from these systems that have an impact on the actor as well. This depends on the type of action chosen, which may be considered as beneficial or damaging by other actors, and the interaction emerging from their responses. Within this framework of human action the following sensitivities exist that relate the impacts on climate change, natural resources, and societal stability to each other:

- Interaction between human values and capabilities (H_H): if increasing effort ($\Delta C > 0$) is beneficial to value ($\Delta V < 0$), positive self-impact ($H_H > 0$) occurs. Provided the result of human action is a value loss $\Delta V < 0$, this may require more effort $\Delta C > 0$ to pursue a value goal V^*, leading to a downward spiral if the action path remains unchanged ($H_H < 0$). Learning can change the action to improve the situation and compensate for the losses. Alternatively, an actor can change the value goal to avoid the negative side effects.
- Impact of human action on GHG concentration (G_H): human actions may lead to increased deforestation and use of fossil fuels or to responses that reduce emissions, e.g. by decreased production. In both cases there is an increase in concentration *G* ($G_H > 0$), though at different scales that can be limited to the natural decay rate $\Delta G < 0$. A net reduction may be achieved through CO2 extraction from the atmosphere and other climate engineering measures.
- Impact of human action on natural resources (N_H): the traditional course of human development is resource-intensive, i.e. higher value and capability require more natural resources ($N_H < 0$). The Environmental Kuznets hypothesis states that beyond a certain level of per capita income the environmental deteriorations begin to decline (see the discussion in Lempert

[20] A fundamental type of adaptive decision rule is $\Delta a = \alpha\ (a^*-a)$, which describes a change in an action variable *a* towards a target action a^*, with an adaptation speed α (for $\alpha = 1$ adaptation occurs in a single step). In particular, the decision rule can represent the adaptation of capabilities $\Delta C = \alpha\ (C^*-C)$, where $C^* = C\ (V^*)$ represents the capability needed to achieve a target value (goal) V^*. For instance, the target value could be to compensate for a value loss caused by climate change.

et al. 2009). Sustainable development seeks a development that does not deplete the natural resource stocks by better protection ($N_H \geq 0$).

- Impact of human action on societal stability (S_H): human efforts in pursuit of human values have a vast range of consequences for society. One possible assumption is that societies are more stable if more human beings are satisfied regarding their values ($S_V > 0$). In return, significant threats to value could undermine societal stability, which may however be compensated by containing the value losses and revising human actions through institutions and governance mechanisms. This is subject to further analysis, in order to identify under which conditions human efforts are directed at an intensification of conflicts or at cooperative action paths that have opposing impacts on societal stability (see the discussion of the stability concept in section 3.6.).

3.6 Social Interactions and Instabilities

3.6.1 Environmental Change and Social Change

Human responses to climate change are embedded in a social environment that includes the social interactions and networks in which humans participate as well as institutions and governance structures. Environmental conditions provide constraints and opportunities for the development of social systems, which in turn exploit, pollute, and manage natural systems. A changing climate that significantly alters these conditions will cause stress to social systems and have an impact on human life and livelihood. Whether societies are able to cope with the impacts will depend on individual and collective responses to climate change and their abilities to adapt to or solve associated problems. Finding new rules and mechanisms that adapt to environmental change is a major challenge.

Understanding these interactions is particularly relevant when addressing the potential security risks and instabilities of climate change. Global warming may lead to security risks and social instability if it outpaces social adaptability. In this context, key issues are the extent of climate change to which societies can adapt and how effective and creative they are in developing capabilities and strategies to deal with altered environmental conditions. The resulting network of interactions can be examined with regard to its stability in order to identify possible cascading events and tipping elements.

3.6.2 Changing Security Contexts and Conceptions

With the end of the Cold War and increasing globalization, the meaning of security has significantly changed, and many actors and factors have been shaping the security discourse in a complex way (Scheffran 2008c, 2011). Comprehensive security concepts now comprise economic, political, social, and ecological dimensions (Brauch 2009a). In a negative sense, security means the ability to protect against danger, threat, and doubt. In a more positive sense, security aims for the preservation of core values. Combining both aspects, security is the difference between chance and risk. A system facing threats can take measures to protect its core values and avoid harmful interference with its structure. To operationalize and specify security, it is important to determine the subject whose security is of concern, the values that are affected, the causes of risk, the vulnerability to harm and fear, and the capability to protect against risks and threats.

Climate change affects the various dimensions of security in multiple ways, which excludes simple statements that suggest a direct causal relationship between climate change and security. Actually, climate change could lead to either fragmentation or further unification of humanity. In developing a more coherent understanding of climate security it is promising to refer to and build on related concepts, such as *common security* (common responses to common threats), e*cological security* (environmental problems as security risks), and *human security* (shielding and empowering people against acute threats).

In this definition of human security (Commission on Human Security 2003:iv), the first task of ‘shielding’ aims at protecting value against risks, and the second task of ‘empowering’ seeks to build the capability to handle future situations – this relates to the capability approach explained in 3.5.3. Broader concepts of human security consider potential losses of human life from a variety of sources (King and Murray 2002, Owen 2004) and narrower ones focus on interpersonal violence in crime, terrorism, and armed conflict (Human Security Report Project 2010). While armed conflict remains relevant because of its potential for the destruction and disruption of societies, not all forms of ‘downside’ risks for lives and livelihoods are covered

(Brzoska 2007). In this way it is also possible to deal with the argument that human security is a vague concept (Paris 2001).

If the impacts of climate change provoke responses that affect the entire society, the consequences may also become an issue of national, international, or global security, and contribute to the securitization of the climate debate. Some impacts may cause governments and the military to take action, e.g. for disaster management, in response to massive refugee flows, or in conflicts induced by environmental stress. Security risks and conflicts are closely related though not inseparable. Some impacts of climate change could undermine the security of nations or people without leading to major conflict, while certain low-level conflicts do not turn into threats for national or international security (sections 3.2 and 3.7.2).

In the debate on climate security, quantitative approaches and measures have so far only played a marginal role. Risk indicators could measure the degree to which countries are affected by weather related loss events. For instance, the *Climate Risk Index* developed by Anemüller, Monreal and Bals (2006), uses the number of deaths and the amount of overall losses in US dollars. Security diagrams couple climate related environmental stress with the susceptibility of societies and the occurrence of ‘crises’, using expert opinions and fuzzy set theory to facilitate the interdisciplinary assessment of climate change impacts (Alcamo et al. 2008).

3.6.3 Societal Instability and Resilience

During the bipolar East-West conflict, stability was a prominent concept in international security and arms control, as expressed by the concepts of crisis stability, arms race stability, and strategic stability. In the complex world (dis-)order in the aftermath of the Cold War, various instabilities emerged (Scheffran 2008c), affecting economic, political, and social systems from local to global levels. In a general sense, stability implies that “minor disturbances are not magnified into a major disturbance but are instead dampened to have only a small and disappearing impact” (Ter Borg and Tulp 1987:50). Stability refers to a change in qualitatively different systemic conditions, such as a transition from peace to war, from conflict to cooperation, or from environmental destruction to sustainability. Apart from the security concept that aims at system preservation by individual actions, the stability concept considers the dynamic interaction with the system’s environment, including interaction with other systems and agents. With regard to the societal implications of climate change, three stability notions are particularly prominent (for a more thorough discussion see Scheffran 2011).

Stability of the Climate System, Ecosystems, and Economic Systems

Article 2 of the *UN Framework Convention on Climate Change* (UNFCCC 1992) demands the stabilization of atmospheric greenhouse gas concentrations at levels that “prevent dangerous anthropogenic interference with the climate system”. This objective is to be realized in a time frame that guarantees three viability conditions (ecosystems adaptation, food security, and economic sustainability). While the first requires an assessment of the stability boundaries of ecosystems within which they can adapt and beyond which they break down, the last two provide socio-economic stability conditions that have to be maintained to avoid disruption of society and the economy (Ott et al. 2004).

Stability against Escalating Threats

In a multi-actor environment, a perceived loss of security for one actor may provoke reactions leading to a loss of security of other actors. Their responses may further result in the spread of insecurity. For instance, the individual actions taken by countries to protect their national security interests by military means may provoke instabilities because they do not adequately take into account the responses from other countries. This ‘security dilemma’ was prominent in the arms race of the Cold War, but similar phenomena may be triggered by climate change if threat perceptions are increased in times of crisis. The concept of crisis stability reduces the motivation to use violence and to take pre-emptive actions. If the degradation of natural resources puts the survival of people at stake, this may provoke the use of violence to protect key resources against competitors. Instead, a peaceful approach would seek to strengthen mutually beneficial cooperation (win-win solutions), e.g. by resource sharing and joint risk management.

Human, Societal, and Political Stability

Societies require rules, regulations, and institutions that maintain social order and ensure that cooperation is beneficial, effective, and predictable. Societal structures that lose credibility and support from the citizens become weak and unable to maintain order. Individuals who experience existential personal losses of life, income, property, job, health, family, or friends may become vulnerable to violating established rules, in particular if there is a low risk of punishment. Thus, personal instability at a larger scale can induce political instability. Societies that are already on the edge of instability are especially at risk. This is particularly the case in failing states that cannot guarantee the core functions of government such as law and public order, welfare, participation, and basic public services (e.g. infrastructure, health, and education), or the monopoly on the use of force. Climate change may undermine the ability of governments to satisfy the needs of citizens and to provide opportunities for wealth and prosperity, and could aggravate other problems such as growing populations, inadequate supplies of fresh water, strained agricultural resources, poor health services, economic decline, or weak political institutions (e.g. Saha 2012). The marginal impact of climate change challenges the problem-solving capacity of societies in climate hot spots, potentially contributing to their collapse (Kahl 2006, Smith and Vivekananda 2009).

Rapid or drastic climate change could overwhelm the adaptive capacity of social systems and lead to periods of instability. A key question is what degree of climate change (measured by the intensity and speed of change in climatic variables) societies can survive and how effective and creative they are in developing coping strategies that translate environmental change into new social rules and structures, thus avoiding or minimizing a transitory period of disorder and related migrations of people who have lost their livelihoods. Societies that are fragile are particularly vulnerable to climate change, as it can lead to a complete failure of the established social order.

To operationalize the stability concept in climate-society interaction, it is useful to refer to the sensitivity concept as explained above (3.3). If a system is more affected by changing conditions (and thus more sensitive), it will more likely become unstable if there is no correcting mechanism that maintains its stability. On the other hand, high sensitivity is a precondition for timely responses if appropriate strategies are chosen. A network of interconnections between the various system variables (Figure 3.5; Table 3.1) can then be constructed using these sensitivities, which can be analyzed in order to understand the impacts of climate events on society.

The sensitivities between key systemic variables and human responses can be combined in an interaction matrix which itself can represent a stable or unstable set of interactions (and can be analyzed by mathematical stability analysis).[21] With this setup it is possible to assess the impacts of triggering events (e.g. mass migrations, extreme weather events, social movements) and to find cascading sequences and tipping points (see section 3.6.5). It is also possible to estimate the probability of future destabilizing events occurring under specified conditions, which can be used to develop an early warning system.

There are many factors influencing societal stability. Adverse developments can trigger the failure of once functioning social systems. Such failures can in turn relate back to the other main compartments of the model framework. For instance, climate change is an issue that the wealthier societies are generally in a better position to handle because of their higher adaptive capacity. They have a choice of either increasing their emissions for their own benefit or reducing emissions for the greater good, while in poor societies survival of the individual usually plays a more important role than environmental conservation. The same holds for the degradation of the environment in the context of the exploitation of natural resources. Nonetheless, the stability of a society is of fundamental importance for the fulfilment of individual human needs. Rules and regulations that guarantee the peaceful coexistence of individual citizens are generally a characteristic of a stable society.

Concepts of resilience can strengthen the social capability of people in their creative and collective efforts to handle the problems associated with climate change (e.g. Adger 2003). In a resilient social environment, the social actors are able to cope with and withstand the disturbances caused by environmental change in a dynamic and flexible way that preserves, rebuilds, or transforms their social order as necessary to retain their livelihood. If these stabilizing mechanisms fail, societies become prone to internal failure, with negative implications for all individuals.

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[21] In our modelling framework, the interaction matrix contains the sensitivities x_y between two variables x and y, and its stability is given by its eigenvalues, which are indicators of the exponential magnification or dampening of the dynamics. For a two-variable interaction with positive self-impacts $x_x > 0$ and $y_y > 0$ and negative mutual impacts $y_x < 0$ and $x_y < 0$, stability depends on the indicator $x_x\, y_y - x_y\, y_x$ which is the difference between the exponentially driving self-impacts and the dampening mutual impacts. With different signs for the sensitivities and additional variables, the mathematical condition can differ (see Scheffran and Hannon 2007).

3.6.4 Models of Social Interaction: Networks, Cascades, and Path Dependency in Collective Action

Climate change is a macro phenomenon that could simultaneously affect and challenge social systems all over the world, possibly inducing a wide range of individual and collective responses. While integrated assessment models often rely on a single rational decision- maker optimizing a global welfare function, the world is shaped by numerous actors who act according to their own interests, capabilities, and rules. Multi-actor settings are increasingly relevant when multiple regions, countries, businesses, or citizens are affected by climate change and make individual or collective responses that lead to social interaction. At the global level of decision-making, the main actors are governments of nations or groupings among them. At the local level, individual citizens and consumers are key players who affect or are affected by climate change. The multi-level process between local and global decision-making is connected through several layers of aggregation (from billions of citizens to a few diplomats representing their countries), with each layer having its own characteristic decision procedures for setting targets and implementing them as real actions (Scheffran 2008a).

In a multi-player setting, game theory provides an optimizing framework for analyzing interdependent decision-making and negotiations among players with respect to climate change. In a dynamic (repeated) game situation the players mutually adapt their targets, values, and actions to those of other players in order to change the outcome in their own favor (Scheffran 2002). For multiple criteria, a conflict may occur if these criteria and the preferred actions are not compatible. Conflicts can be diminished by pursuing compromising actions that improve all criteria (win-win) without being optimal in all criteria. While game-theoretical solution concepts are adequate in environments with only a few players and control variables, they are difficult to apply in settings of multiple options and players with bounded rationality. In the case of multiple value functions, multi-criteria decision- making derives solution concepts such as Pareto optimality, seeking the set of combined actions that does not allow further joint improvements for all players.

Various tools have been developed in complex systems science that can be applied in analyses of social phenomena in climate policy (Scheffran 2006b). In particular, these help to assess the impact of human responses to environmental change and the social interactions that result from these responses. For a large number of homogenous actors, methods and concepts from statistical physics and non linear dynamics have been used to describe phenomena of complex adaptive systems such as self-organization or micro-macro phase transitions.[22]

Agent-based modeling (ABM) analyses patterns of collective action emerging from large numbers of agents following particular rules of behavior. Depending on stimulus-response mechanisms at the micro level, complex social patterns emerge in virtual landscapes of artificial societies at the macro level. ABM is often useful in situations where the future is unpredictable and traditional analytic methods for decision- making are least effective.[23] Applications range from moving crowds and traffic systems to urban, demographic, and environmental planning. Unlike game theory, in which the selection of options is determined by the rule of optimizing utility, ABM faces the difficulty of selecting among a large number of possible rules to adequately describe real world decisions. To avoid the problems of both approaches, it is sufficient to combine dynamic games and ABM, with value functions and decision rules co-evolving. Multi-agent models have gained increasing interest in social modeling, including environmental management and climate policy.[24] They permit the coupling and embedding of social interaction into environmental models, taking into account the adaptive, disaggregated nature of human decision-making as well as collective responses to changing environments and management policies.

Social network analysis (SNA) describes the connectivity of nodes and links between actors and is appropriate for the structural analysis of social interaction. SNA has been increasingly applied to the study of conflict (Flint et al. 2009, Maoz 2010) though less so in the context of climate change. Models of network diffusion that have been developed to analyze the spread of diseases can be used to study the spread of social behavior patterns, and this is relevant to describing the proliferation of violence and conflict as well as the diffusion of technical innovations and social practices for climate mitigation and adaptation.

In pursuing their individual interests, multiple actors could run into a “cascading sequence of events where an action taken by one actor provokes more intense actions by other actors” (Scheffran 2008c:19). Tipping elements in the climate system could induce a sequence of instabilities that trigger other tipping elements in social

[22] For instance, Helbing (1995); Weidlich (2000); Schweitzer (1997).
[23] Axelrod (1984, 1997); Cederman (1997); Ostrom (2000); Janssen and Ostrom (2006).
[24] Weber, Barth, and Hasselmann (2005); Weber (2004); Patt and Siebenhüner (2002); Billari et al. (2006).

systems. Along the pathways in our integrated framework, seemingly ‘minor’ events could provoke major qualitative changes of the system, which is characteristic for chaotic systems. A self-reinforcing chain reaction could increase the potential risk of social cascades that could put the whole system at risk.

Informational cascades occur “when it is optimal for an individual, having observed the actions of those ahead of him, to follow the behavior of the preceding individual without regard to his own information” (Bikhchandani et al. 1992:992). Likewise in a cascade agents learn from the behavior of other agents and follow them in the way they act (Bikhchandani et al. 1998), thus leading to a collective transition to a qualitatively new social structure. Real-world examples of informational cascades can be found everywhere, from the stock market and voting patterns to the fashion industry. One explanation of why humans pay so much attention to choices made by others is that “imitators may have as high a long-run ‘fitness’ as optimizers” (Conlisk 1980:275), which however only works if the imitated behavior is successful. Richerson and Boyd (1992) showed that in many instances social learning is preferred by natural selection. If the choices and actions of others influence our own decisions, then with an increasing size of the population tipping points in collective interaction are more likely and undermine the stability of the whole system. An example was the financial crisis of 2008, in which reckless lending practices by financial institutions in the United States contributed to a global economic downturn. Similarly, the interaction between rating agencies and governmental decisions regarding the crisis of confidence in the creditworthiness of Greece and other countries has challenged the stability of the Eurozone since 2010. In early 2011, a series of riots in North African countries, partly related to a rise in food prices, challenged the stability of this region.

In the future, climate change could add to these interactions and trigger a cascading sequence of climate related events (e.g. extreme weather events, food insecurity, mass migrations, and social movements). On the other hand, this approach may also be suitable for studying collective and cooperative interactions in a sustainability transition induced by climate change.

The theory of cascades and social networks can be related to path dependency (Beyer 2005, Kominek and Scheffran 2011). This concept implies that social actors are locked in certain pathways of action that are self-enforcing and hard to change individually. While former approaches did concentrate more on historical analysis of event sequences (thus looking backward), the approach of ‘path creation’ argues for more forward-looking research that considers the beginning of an evolving path and the options for shaping it deliberately, particularly relevant for transformations induced by climate change. An extended approach would connect the macro-level phenomenon of path dependency (such as coalition building or institution formation) to the micro-level effects of actor behavior and how path dependency shapes the decision-making processes of individual actors (Kominek 2009, 2012), using concepts from social psychology. Cascades triggered by catastrophic events can be shaped by institutional responses in one way or the other. In natural disasters international aid may help a large group to survive and thus stabilize the social system. On the other hand, aid in times of crisis may lead to competition or even struggle among those in need, something which has happened in the case of several natural disasters (WBGU 2008).

To address the security risks, it is crucial that the world’s key players cooperate in finding solutions to the climate challenge, managing the transition from individual competition to collective action. For instance, cooperative approaches include the international transfer of investments and technologies so as to shift the composition of the energy system towards emission reductions (Ipsen et al. 2001). In negotiations, agents adapt to each other and seek common solutions leading to mutual benefits, reduced costs, or diminishing risks. To avoid the prisoners’ dilemma that blocks cooperation between two players because of short-sighted individual behavior, states need binding and verifiable agreements.

The collective action problem is to agree on emission paths that avoid dangerous climate change and make sure that cumulative emissions by all human beings will not exceed this limit. Assuming that there is an agreed cap on aggregate emissions, it is a challenge to find institutional mechanisms to guarantee that individual limits are assigned to each actor and that their compliance is ensured to avoid the tragedy of the commons. Sustainable development strategies often fail due to their inability to adequately take social interaction such as conflicts, dialogues, negotiations, coalition formation, and institution building into consideration. Joint action could rather preserve natural resources and support a sustainability transition if individuals cooperate and coordinate their actions for an effective and fair share of the resources. To address the underlying social dilemmas, new rules, norms, and innovations need to evolve. Which form of interaction prevails depends on the rules of communication and the institutional settings as well as on the tools available before, during, and after the interaction. Coalition formation describes the transition from individual to collective action as a bargaining process, in which the probability of joining a coalition increases with the value actors expect from it.[25]

The integrated assessment framework highlights the importance of human responses and social interactions as key variables for analyzing the impact of climate change on security, societal stability, and conflict. They are a major reason for the circular and endogenous character of the framework, and they have a significant impact on climate-society interaction and its stability. Whether the impact of climate change or natural resources on the human and societal sphere (given by the sensitivities C_S, S_C, N_S, and S_N) is positive or negative depends on the preferences and strategies of people and can be quite different, even under similar circumstances. This is an expression of the non deterministic behavior of human societies and their freedom of choice. In particular, the consequences of climate change may tempt some people to use violence while others work together more closely, depending on individual preferences and capabilities shaped by previous rules and experiences.

Rapid or drastic climate change can challenge the stability of social systems, requiring new rules and responses, but it may also create new opportunities for development. Fragile societies are particularly vulnerable to climate change, which can lead to a complete failure of the established social order if there is no capacity for adapting and maintaining stability. In this context it is relevant to know how fast and how intense the responses are compared with the speed and intensity of climate change. Provided that societies develop effective and creative coping strategies, climate change may also offer opportunities for constructive societal change. The following issues are of key importance in this context:

- Alternative approaches could build on participative concepts of sustainable development and peace-building that support people in regions affected by climate change in their creative efforts to sustain their livelihoods.
- Adaptive strategies could be designed to restore livelihood and maintain resilience under changing climatic conditions, e.g. by utilizing existing natural resources more efficiently, growing and producing new types of natural resources, providing a sustainable energy supply, and improving disaster management.

[25] Göbeler and Scheffran (2002); Scheffran (2006a); Eisenack, Lüdeke, Petschel-Held et al.(2007).

- Technological change plays a key role in human-environment interactions. No less significant are innovative social mechanisms that are more effective in facilitating the livelihood people need, including governance and institutions.

In the following section, we will sketch a model framework for the analysis of social interactions in the context of climate change. Rather than delving into the mathematics of the model, we will discuss the basic relations in more qualitative terms.

3.7 Model Framework of Social Interaction and Conflict

3.7.1 The Dynamics of Social Action and Interaction

In the following, we expand the action cycle described in Figure 3.7 towards a model framework of social action and interaction. Social actors respond to climate change within a natural and social environment according to decision rules used to select action paths depending on their values and capabilities. Thus, the social actor is characterized by the following elements (Figure 3.8):

- capabilities and efforts (*C*) available to the actor that can be used in actions;
- priorities and rules (*P*) of the actor for selecting among possible action paths;
- values and goals (*V*) to evaluate the impacts of actions and define targets for future actions.

Once an action is realized from the interplay of these variables, it affects the system environment *X* of the actor. This in turn has an impact on the actor's values and capabilities.[26]

Based on the key model elements, the authors will in the following refer to the model as the VCAPS (*Values and Capabilities of Action paths and Priorities in System environments*) model.

This model can be used to describe the interaction between multiple actors *i*, each with their values and goals (*Vi*), capabilities and efforts (*Ci*), action paths *(Ai)*, and priorities and rules (*Pi*). The action paths selected by each actor affect their system environment, which in turn has an impact on other actors (Figure 3.8 right for a two-actor interaction).[27]

[26] The respective couplings are given by the key sensitivities: unit values $v_x = \Delta V/\Delta x$, unit costs $c_x = \Delta C/\Delta x$, and the value-cost ratio $v_c = v_x/c_x = \Delta V/\Delta C$ of environmental change.

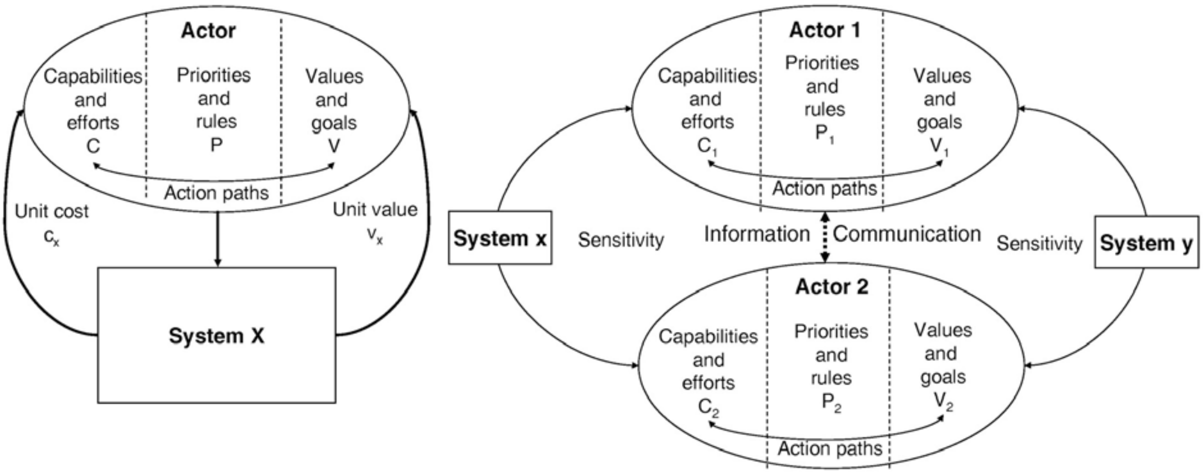

Figure 3.8 Interaction between a single actor and a single system (left) and between two actors and two systems (right) (the authors)

These impacts are critically dependent on the action paths selected, and thus on the respective priorities and rules of behavior. The actors are also interconnected directly through communication processes for exchanging information, which can be also treated as actions (e.g. 'speech acts'). The impact of climate change can now be expressed within this framework of human action and social interaction (Figure 3.9).

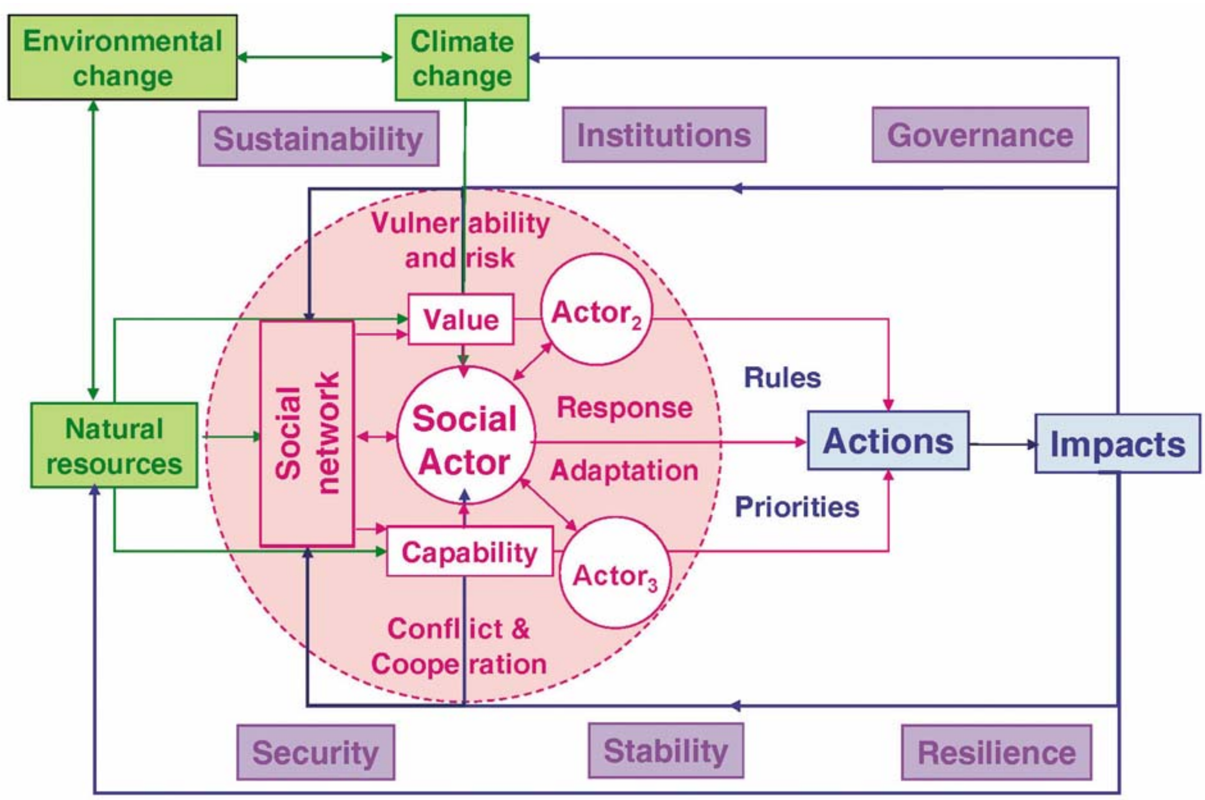

Figure 3.9 Framework of interaction between a social actor and the natural environment (the authors)

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[27] This impact can be measured as the value change $\Delta V_i = vc_{ij}\,\Delta C_j$ for actor *i* induced by the capability ΔC_j used by actor *j* (effort) along the respective action path. The mutual impacts vc_{ij} are key sensitivities that determine how the value of one actor is affected by the effort of other actors.

Since climate change influences the natural environment and the availability of natural resources, it has an impact on the capabilities, values, and actions of social actors. In response to and to adapt to the changing environment, a social actor selects among potential actions paths according to decision rules that incorporate his/her values and goals (including risks avoided and expected benefits), the capabilities to take these actions, and the priorities shaped by personal and social experiences. There is a variety of actions that social actors can take in response to climate change. Some of these measures may cause additional problems (e.g. biofuels, nuclear power, climate engineering, migration, violence) that increase the likelihood of resistance and conflict. To minimize adverse consequences, concepts of stability, security, resilience, peace, and sustainability are taken into consideration.

Adaptive responses to climate change are shaped by the social context in which social actors live, including livelihood, social networks, institutions, and governance. Human beings are facing the risks of climate change not as isolated individuals but as members of social groups that can help protect individuals against risks. Furthermore, they can mutually enhance their capabilities through social adaptation mechanisms that lead to reduced social vulnerability (Mearns and Norton 2009).

The development of social vulnerability and adaptation depends on the mutual impacts on other actors and how the social actors respond to each other according to their rules. The action-reaction dynamics could lead to complex social interactions with the natural environment and between the social actors in their social environment, including security risks and conflicts. Since social systems have had to go through a social evolution process in the past, the priorities and rules have also evolved and have been shaped by societies and their path dependencies.

3.7.2 Conflict and Cooperation

Conflict often emerges from incompatible actions, values, behavioral rules, and priorities of actors who fail to reduce their differences and tensions to tolerable levels. The actions taken may undermine each other’s values and provoke responses that generate further losses. A conflict escalates if actions by the parties in conflict aggravate the tension and intensity of the conflict, corresponding to an inherently unstable interaction. If unresolved, conflicts consume a considerable amount of resources, pushing parties in conflict towards extreme actions such as the use of violence, until the capability to act by some actors is exhausted or destroyed if it is not replenished by some processes. Conflict resolution can help reduce the conflict tension and stabilize the interaction by involving actors in learning and adjusting their actions until agreement is reached. Cooperation is a process in which actors adjust their goals and actions to achieve mutual benefits. The transition from conflict to cooperation requires adaptation towards common positions and mutually beneficial actions that stabilize the interaction. Whether this transition is successful depends on the governance capacity of societies to prevent or manage conflicts.

Also, it is difficult to assess whether and under which conditions climate change contributes to conflict because it depends on the factors described in previous sections. Furthermore, there is a range of possible kinds of conflict related to climate change:

1. dispute over scientific predictions und the uncertainties of climate change;
2. conflicts induced or strengthened by the risks of climate change;
3. conflicts over selecting effective mitigation strategies;
4. conflicts over adaptation to and damage limitation of climate change;
5. conflicts between emitters and victims over the fair distribution of the costs, risks, and benefits of climate change;
6. conflict over the impacts of climate protection strategies such as nuclear power, bioenergy, and climate engineering.

In all conflicts, actors can apply a number of capabilities in their actions, with violence as the most extreme form of action. While the second category of conflict caused by climate security risks only occurs when climate change happens at a relevant scale, the other five may be already imminent at earlier stages because they deal with the anticipation of and possible responses to climate change. Regarding the conflicts caused by climate security risks, four ‘conflict constellations’ are particularly prominent: degradation of freshwater resources, decline in food production, increase in storm and flood disasters, and environmentally- induced migration (WBGU 2008). Others may however be no less significant (e.g. biodiversity loss, rise of sea level). The underlying assumption is that climate change reduces critical resources and infrastructures that are essential for the provision of human needs and thus undermines societal stability (along the chain $\Delta N < 0 \rightarrow \Delta H < 0 \rightarrow \Delta S < 0$). However, the WBGU (2008) also notes that climate change could unite the international community in setting the course for a dynamic and globally coordinated climate policy.

Whether conflict or cooperation prevails depends on the responses of each actor. These are represented by decision rules and action priorities and by the actor's potential for learning and adaptation. From a social network perspective, the mutual impacts (linkages) between actors matter[28]:

1. If two actors are disconnected, they are independent and have no impact on each other's values. In this neutral relation the required effort is not influenced by other actors and thus is kept constant as long as each actor's own value goal does not change.
2. In a competitive or even hostile relationship, effort needs to be increased to compensate for the effort of the other actor, which is experienced as a loss.
3. In a cooperative or friendly relationship, both actors benefit from each other and may reduce their own efforts accordingly to realize their common goal.
4. In a mixed case, one actor cooperates and the other does not, which in some cases may still be better than mutual conflict.

In a competitive case a state of mutual satisfaction is still possible, but the question is whether that state is within the admissible range of efforts. If an agreement is not possible even with maximum effort, there is an unresolved conflict unless actors acquire more or different capabilities or change their own goals. Alternatively, one or both actors can change their behavior by switching to other action paths that make their actions more efficient and less threatening to other actors, thus increasing the likelihood of reaching an agreement.[29]

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[28] In our interaction model, the combined impact of all actors' efforts ΔC_j on the value $\Delta Vi = \Sigma j\ vc_{ij}\ \Delta C_j$ of actor *i* strongly depends on the couplings vc_{ij}. These are measured by the couplings vc_{ij} between a pair of actors *i* and *j,* which can be positive, negative, or zero. If actors pursue particular value targets (e.g. the goal is to compensate for climate-induced value loss $\Delta V_i = -\Delta V_i^*$), this defines a set of linear equations for the respective capabilities as a function of the capabilities of other actors that determine the responses of efforts by the actors to each other. Adaptation rules for the application of capability (effort) of actor *i* typically have the form $\Delta C_i = \alpha\ (C_i^* - C_i)$, i.e. capability C_i is adjusted to targets C_i^*, provided this is possible within a given capability limit.

[29] In mathematical terms, let sensitivities $vc_{11} > 0$ and $vc_{22} > 0$ be the positive "self-impacts" of the efforts of actors 1 and 2 regarding their own values, and $vc_{12} < 0$ and $vc_{21} < 0$ be the negative mutual impacts on each other's values. Then this would be a competitive interaction. A switch to cooperation would require that the mutual impacts become positive, thus switching from an adverse to a friendly relationship. Even under conditions of competition, it may be possible to move the satisfaction point into the admissible range of efforts by increasing the self-impacts, e.g. by improving efficiency. For an unstable conflict, given by the instability condition $vc_{11}\ vc_{22} - vc_{12}\ vc_{21} < 0$, an agreement point does not exist and the conflict escalates to utmost efforts unless actors change their goals. For more than two actors the stability of the more complex interaction matrix can be determined based on eigenvalue analysis.

Whether actors are able to achieve their goals not only depends on the impact of climate change and the actions of others but also on the self-impacts, i.e. how much the effort of one actor affects his or her own values. Very powerful (high capability) and efficient actors (high positive self-impact) are able to digest the impact of climate change or the adverse impact of other actors but only within the limit of their own capability and sensitivity. Using the sensitivities, it is possible to determine the structure of the social network as well as the social dynamics between multiple actors which are connected to the overall environmental system dynamics. An example is illustrated in Figure 3.10.

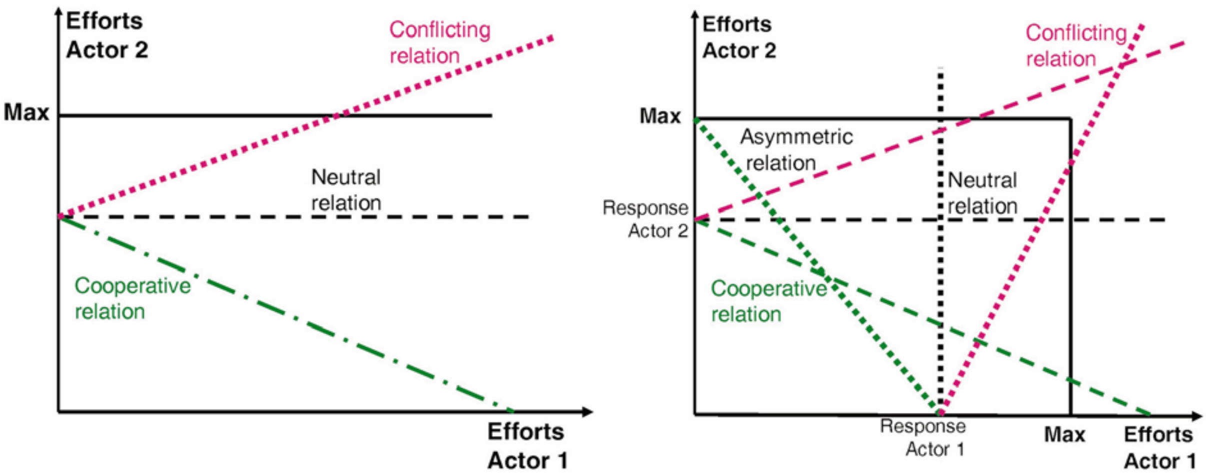

Figure 3.10 Conflicting and cooperative relationships between two actors (modified from Scheffran and Hannon (2007). Both actors use their efforts to reach their individual value goals on the basis of given action rules that depend on the effort of the other actor. In a conflicting relationship efforts mutually increase, in a cooperative one they mutually decline. In asymmetric cases one actor provokes conflict while the other maintains cooperation. A neutral relation implies that the effort of one actor does not depend on the other. The response functions shown are for efforts of (a) actor 2, (b) both actors

Two actors share a common resource such as energy, land, or water that is important both for its value and capability. The more effort one actor invests in acquiring the resource, the less is available for the other actor, who may then also have to invest more to maintain given resource needs. In this conflicting relationship, the question is whether there is an agreement point of resource sharing within the capability boundaries. In a situation of unresolved conflict, one option is to use violence to either grab a higher resource share or to destroy the capability or resource access of the competitor, thus making the impact on the competitor even more negative. The situation may be further aggravated by climate change affecting the reproduction of natural resources and so moving the required efforts of both actors and the agreement point further upwards.

As an alternative, actors could improve resource efficiency (represented by increasing positive self-impact), thus achieving value goals with fewer efforts, shifting the response curves downward (Figure 3.10). If in this process actors help each other by investing in each other's resource efficiency, this would be a switch towards a cooperative relationship. Furthermore, actors may reduce their required value goals to facilitate agreement, but this is not feasible if the existential minimal thresholds of fundamental human needs have been reached. Finally, climate change may diminish the available maximum capability and restrain the action spectrum, which can make any agreement point impossible to reach even with cooperative relationships and changing goals, and may possibly lead to a struggle for survival by some of or all the actors. This framework allows the assessment of possible conditions and scenarios of conflict and cooperation under climate change based on assumptions of the various sensitivities for actions.

3.7.3 An Extended Interaction Model of Production and Conflict

While the VCAPS interaction model introduced in the previous section is able to explain in qualitative terms some of the issues in climate-security interaction, there are some aspects that need to be incorporated in an expanded version of the model to represent important dimensions of reality. In particular, these refer to economic production and consumption processes, including natural resources and the accumulation of wealth and capital, the use of violent force in conflict, human population and migration, and the role of technology, as well as political processes such as negotiations, governance, and institutions. While the basic structure of the VCAPS model with its dynamic interaction of values, capabilities, and action paths is maintained, several additional specifications are now included. •

- Social actors can represent any social entity, from individuals to the world, such as countries, businesses, communities, or coalitions. Population *L* measures the number of individuals associated with the social actor, e.g. through membership, nationality, work, or financial support. For a country it comprises its citizens, for a business the people employed (labor force).
- Capability *C* includes the productive capital belonging to the social actor, including the controlled natural resource stock *N* (decaying or regenerated by natural processes), physical capital *K* (including technical devices and

facilities), human capital H (knowledge and skills), and social capital S (social networks and structures).

- In the production process through the use of capability ΔC (effort) additional value ΔV is generated that can be either consumed or reinvested in capability building to compensate for its depletion or support its growth. Alternatively, value can be accumulated (saved) as wealth W for consumption or investment at a later time. Part of wealth ΔW may be invested in capability-building or used to buy goods produced by other social actors for a market price.

While value, effort, and investment are flow variables for a given time period, resources, wealth, and capability are stock variables that can grow and decay over time. The system environment of the social actor is characterized by the following elements that determine the possible action paths (P):

- In the production process, goods Q comprise all produced items, including commodities and services for consumption. Producing goods requires a production capability C, which is partly used to cover production costs and efforts ΔC, including labor, salary, and other production factors. Production may also be increased through higher capital efficiency. For instance, agricultural production is a function of agricultural land, water use, labor, and other production factors (capital, machinery, energy, fertilizers). Key limits to production are the available land and water that can be extended by improving land productivity and water efficiency.
- Destructive forces F are not produced for consumption or regeneration but are designed to threaten or damage other actors, to capture or destroy their key assets (such as capability, wealth, goods, population, or force), or force them to take certain actions beneficial to the attacker. Such benefits are important to justify the costly use of force. Whether this strategy is successful depends on the force exchange between the actors. Some systems and technologies associated with force may be dual-use items.
- Natural resources ΔN extracted (harvested) from the available natural resource stock N add to production capability. Environmental pollution ΔG is the amount of emitted substances that may accumulate in the environment as pollution stock G. Greenhouse gases act as a driver of temperature increase and thus climate change, affecting capability and wealth. Sustainability

concepts define limits for resource extraction and pollution that respect the natural reproduction rates.

- Part of the human population may migrate (*M*) into areas of other social actors and add to labor and human capital there if they are adopted. Migration could also add to scarcity and conflict, in particular if it strengthens existing conflict lines (e.g. along ethnic differences). The decision to migrate depends on judgment regarding the migrants' capability and motivation in their target areas compared with their areas of origin, including possible risks of conflict or environmental change avoided, or values gained through higher income, mobility, and transportation capacity along the migration pathway. While some models cover partial aspects of human migration, there is still a need for more research to understand the complex phenomena associated with migration (Piguet 2010).

The interaction between these processes is shaped by a number of intervening factors that may be used to control these dynamics:

- Technology is a key source of innovation for production or destruction affecting the linkages and sensitivities in the model by favoring certain pathways of action towards higher efficiency.
- Knowledge, information, and communication are which are important for providing social actors with an understanding of the state of the system variables and their interaction, essential for taking appropriate actions.
- Governance and institutions play a key role by restraining the adverse risks of social interaction (such as pollution and conflict). They also organize collective action to make decision-making, production, and market processes more efficient and
- effective. Furthermore, they maintain, stabilize,
- and protect social and political order. Global governance can organize the coordination of capabilities, values, and action paths for multiple actors across the multi-level process of climate policy.

The main causal linkages are represented in Figure 3.11 for an interaction between two actors. The complexity of this graph reflects various issues that have not been integrated in previous models.

The framework allows for assessing the relationship between climate change, natural resources, economic production, and the use of violent force. Several impact chains and feedback loops are relevant here; only a few are mentioned here by way of example:

- production cycle: $C \rightarrow Q \rightarrow V \rightarrow W \rightarrow C$
- climate change: $C \rightarrow Q \rightarrow G \rightarrow N \rightarrow C \rightarrow Q \rightarrow W \rightarrow C \rightarrow L$
- climate-migration link: $G \rightarrow W \rightarrow L \rightarrow M$
- use of force against production: $Q_1 \rightarrow F_1 \rightarrow C_2 \rightarrow Q_2 \rightarrow W_2$
- exchange between actors (X: capability, goods, wealth, labor, technology): $X_1 \rightarrow X_2$.

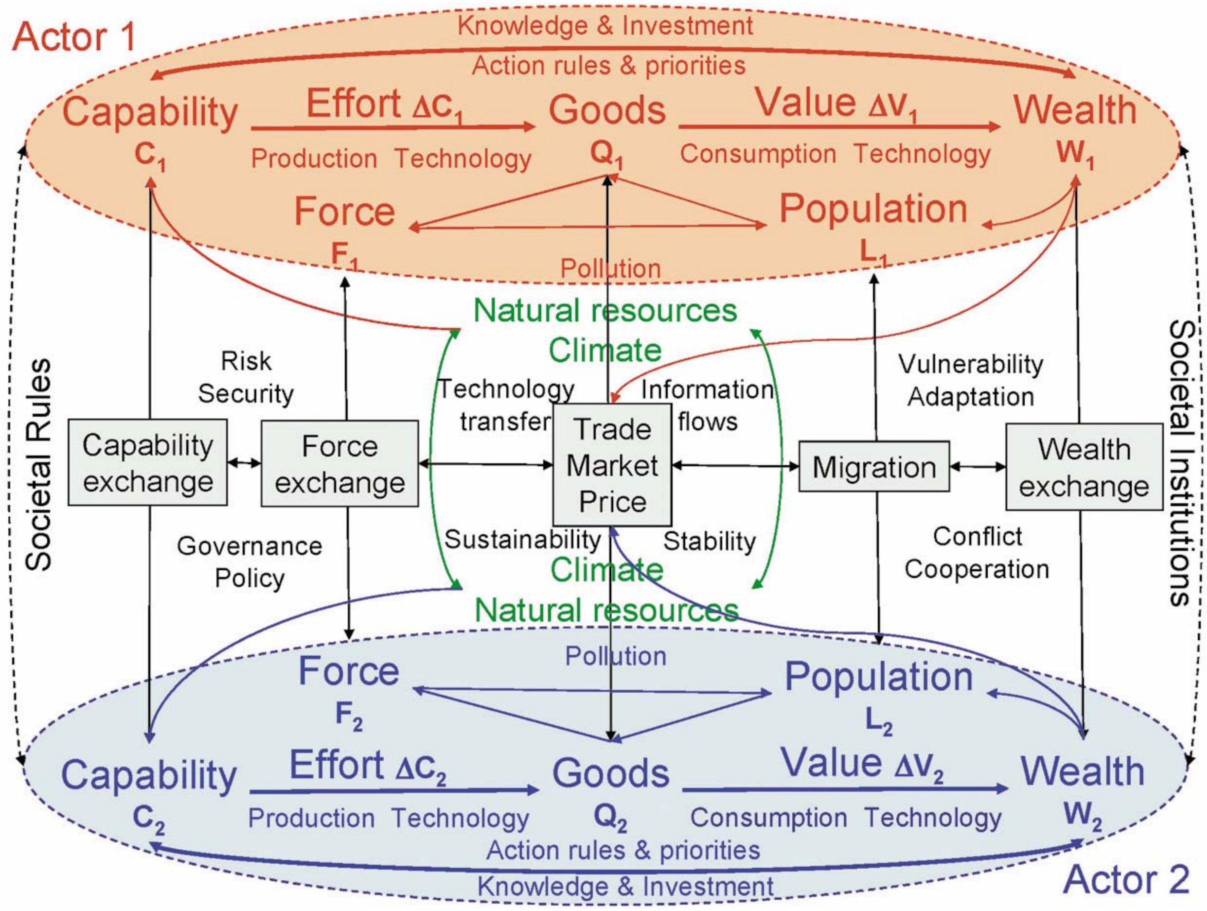

Figure 3.11 The extended two-actor interaction model (the authors)

More complex chains can emerge from connecting them (e.g. climate change and the production cycle, use of force and migration, production and cooperation). Assessments of these resulting chains make it possible to study the dynamics of certain decision rules that cause pathways to be selected in a multi-actor setting. For instance, there is a wide range of goods that can be produced (including force) and various actions that can be taken (including migration and the use of force). Freedom of choice may be restrained if actors follow predetermined decision rules and paths.

Most prominent is an optimization rule in which investments and efforts are chosen to maximize value (utility) or minimize risk. Other rules adapt control variables to certain goals or dominant pathways in a society, leading to path dependency (Kominek 2012).

While the full model demonstrates the complexity of the interaction, sub-models may cover partial aspects such as economic growth, market processes, natural resource extraction, or force exchange and violent conflict. To connect to real-world phenomena, the modeling framework is to be embedded in an interactive laboratory for climate-security analysis that combines data analysis, modeling and simulation, decision support and strategy development, regional participatory assessment, and stakeholder involvement (Figure 3.12).

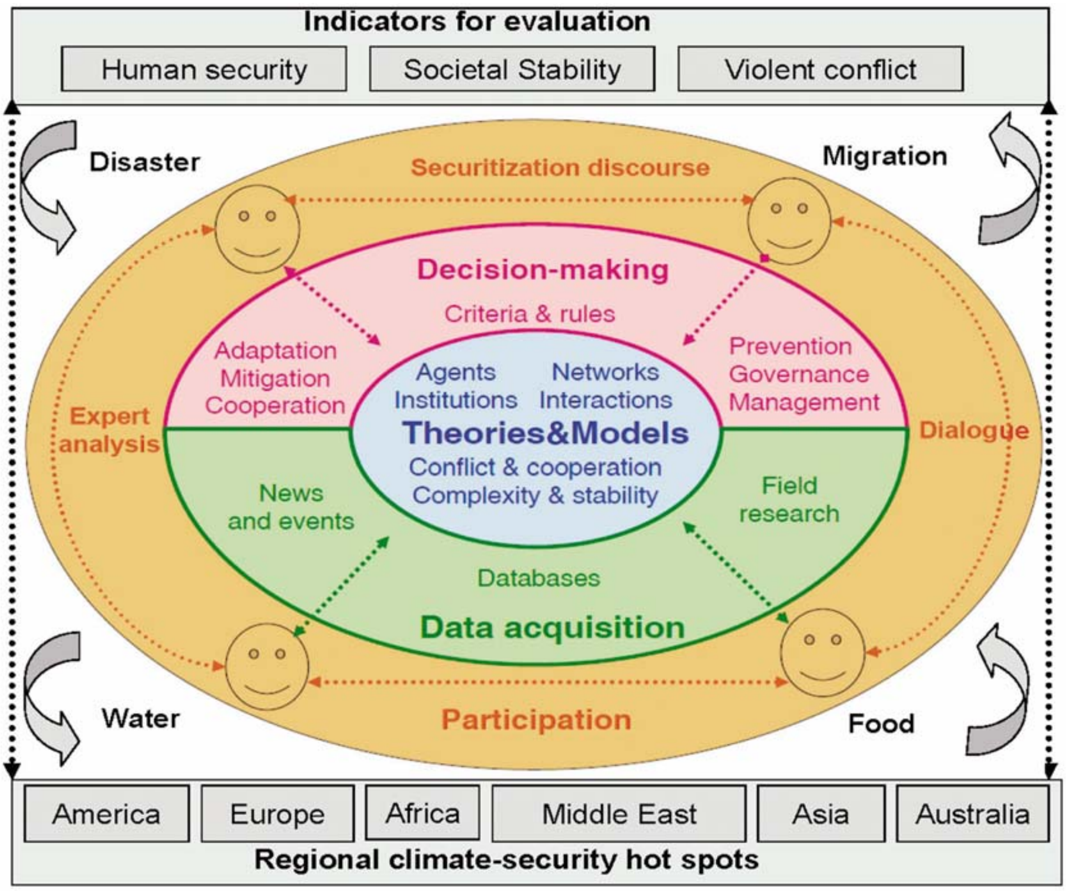

Figure 3.12 Scheme of a laboratory for climate-security analysis (the authors)

Including experts and stakeholders from the regions of concern is essential for a participatory assessment of climate impacts (Scheffran and Stoll-Kleemann 2003, Stoll-Kleemann and Welp 2006). 'Mediated modeling' (van den Belt 2004) could identify the key links and variables and generate new data to draw impact graphs and risk maps as well as develop possible solutions that could be incorporated into adaptation and planning processes.

The full model framework developed in this section and schematically depicted in Figures 3.11 and 3.12 is a tool that does not yet exist in this form. Therefore, current research deals with the setup of the individual segments in partial models that can subsequently be combined to achieve the goal of a comprehensive model of climate-security interaction. While full realization and implementation of this conceptual framework is a task for future research, in the following section we will relate some of the theoretical concepts to a particular example.

3.8 Case Study: The Nile Conflict

To specify and exemplify the general assessment and model framework, climate-security interaction will be discussed for the larger Mediterranean region with a particular emphasis on the water conflict in the Nile river basin. A reduced form of the model is used to describe key features of the conflict and the potential dynamic interactions among major actors. A more detailed assessment will be subject to future research.

3.8.1 Resource Conflicts in North Africa, the Middle East, and the Mediterranean

The larger Mediterranean region (southern Europe, North Africa, and the Middle East) will be severely affected by global warming. Rising temperatures are expected to exacerbate existing pressures on limited water resources because of altered rainfall patterns and loss of snow and glacial meltwater. This adds to the existing problems of desertification, water scarcity, and food production (Brauch et al. 2003, IPCC 2007a). Water scarcity has a negative impact on agricultural and forestry yields and limits the output of hydropower. Heat waves and forest fires compromise vegetation cover and add to existing environmental problems. Ecosystem change affects soil quality and moisture, the carbon cycle, and local climate. Population pressure and water-intensive activities such as irrigation already impose a considerable stress on water supplies. This poses dangers to human health, ecosystems, and the national economies of countries. Within the Mediterranean region there are significant differences with regard to vulnerability and problem-solving capacity. Southern Europe is characterized by relatively high economic and social capabilities, which can be further backed up by support from the EU (Brauch 2006a). In contrast, the environmental situation in North Africa is significantly worse. There, climate change interacts with the region's other problems including high population growth, a substantial dependence on agriculture, and weak governance (Link et al. 2010).

The Middle East is plagued by deeply-rooted violent conflicts and by a lasting water scarcity (Shuval and Dweik 2007). The arid climate, the imbalance between water demand and supply, and the ongoing confrontation between key political actors intensify the water crisis, but exaggerated statements about 'water wars' have to be questioned. Competition over shared resources has been observed for the rivers Nile, Euphrates, and Jordan. The Jordan river basin has been considerably contested between Israel, Jordan, Lebanon, Syria, and the Palestinians. The region's conflicts are largely determined by political differences, and water related problems represent an additional dimension that may contribute to either an intensification of conflict or a change in behavior towards cooperation. Besides technical and economic solutions that will increase the supply or decrease the demand of water, a resolution of the water crisis can be most effectively achieved by offering joint management, monitoring and enforcement strategies, and by a greater transparency of transboundary water data (Medzini and Wolf 2004). However, the long history of conflict has resulted in deep distrust in the region, impairing the chances of cooperation (Brown and Crawford 2009).

3.8.2 Water Conflicts in the Nile River Basin

Reduced water supply over an extended period carries a conflict potential for the countries in the Nile river basin (Mason 2004). Egypt depends on the Nile for 95 per cent of its drinking and industrial water and could feel threatened by upstream countries that deplete the water resources from the river (Piontek 2010). While this increases the chances for political crisis and violent clashes (Brauch 2006a), it also increases the need for agreements to regulate water distribution. Lack of usable land and water resources adds to impoverishment and forces people to move from rural areas to cities. The agriculturally quite productive river delta is at risk from sea level rise and salinization.

Egypt and especially Cairo are highly vulnerable to various impacts of climate change. It is estimated that Egypt could experience a severe loss in agricultural productivity as a result of water scarcity and land degradation induced by climate change. Wheat and maize production in Egypt could significantly drop by the middle of the 21st century. Even without the mounting demographic pressure, this may intensify competition over the remaining arable land. The capital's infrastructure is already under pressure due to the city's rapid growth, especially with respect to water availability, hygiene, waste disposal, and housing. Climate change is likely to worsen existing problems. A 0.5 m rise in the sea level of the Mediterranean could displace between two and four million Egyptians (FoEME 2007), most of them seeking refuge in Cairo's suburbs. Water scarcity and lower agricultural productivity in the Upper Nile area also add to pressure to migrate from the rural areas to Cairo and contribute to the degradation of sanitary conditions and increasing social unrest.

The interactions and causal relationships between the various driving factors influencing societal stability can be visualized in an impact diagram that represents the systemic factors and interactions in our VCAPS model framework.[30] Figure 3.13 depicts the essential variables and relationships of the water conflict in the Nile region. It shows the key quantities and their interactions that need to be taken into account when the underlying model framework is converted to a concrete numeric model of water allocation decisions in this geographic region.

Changes in climatic conditions influence water and land availability, which in turn affect economic production. Human welfare and consequently societal stability depend on wealth; any deterioration of the economy has negative implications for society as well. Since water availability and thus the conditions for agricultural production depend on water use further upstream, two main geographic regions (upstream and downstream) are distinguished.

[30] A green arrow indicates a positive impact (sensitivity), i.e. an increase of one factor causes an increase in the factor that is affected (indicating a positive sensitivity). A red arrow represents a negative impact, which implies that an increase in a particular variable leads to a decline in the variable that is affected. For a black arrow the impact is ambivalent. No arrow implies that no relevant impact is considered.

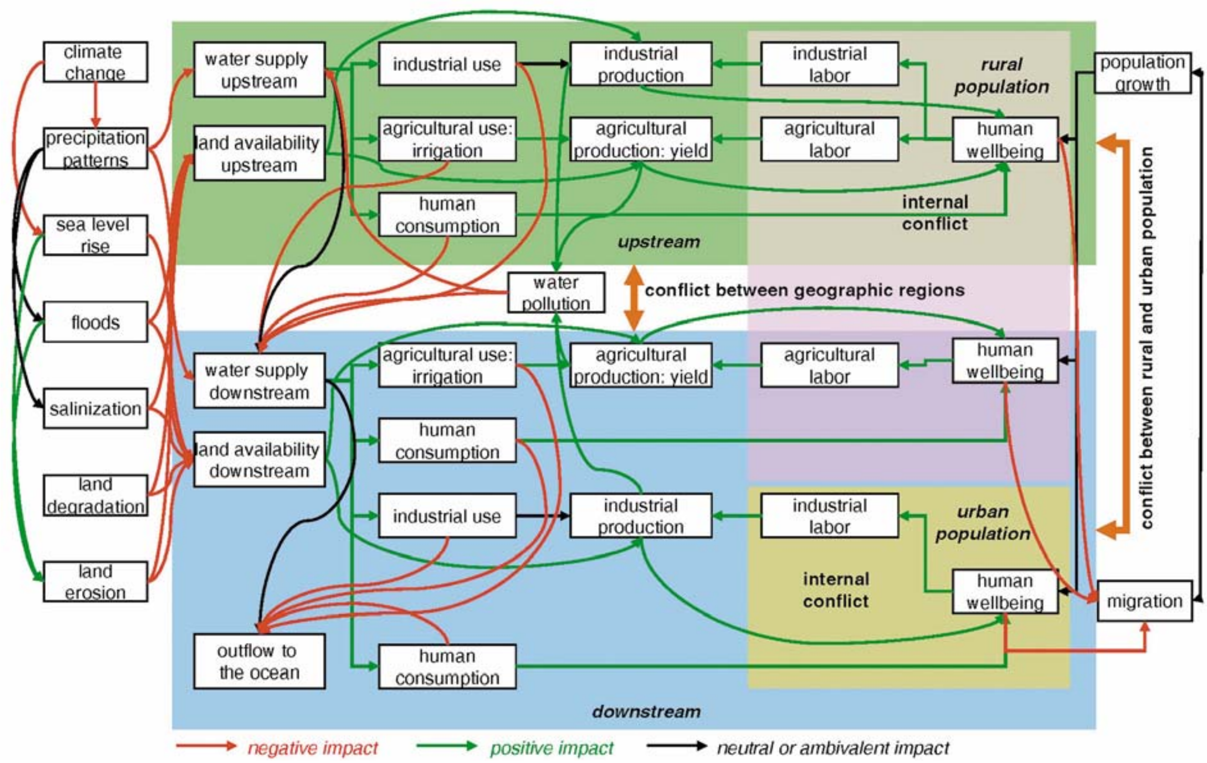

Figure 3.13 Schematic overview of systemic factors and interactions in the water conflict in the Nile river basin (the authors)

Also, there is a differentiation between the population of rural and urban areas along the Nile, as economic activities differ substantially and the effects of climate change vary accordingly. Any large-scale change in the structure of society caused by migration or population growth triggers feedbacks that affect the economic output and subsequently the distribution of the remaining land and water resources. Conflicts between the various actors can arise on different levels. First of all, there is tension between geographic regions. Increased use of resources in the upstream region diminishes water supply and the conditions for successful agricultural production downstream. Also, tensions may build due to the distinctly different structure of the populations in the rural and urban areas. These may increase in intensity if migration between these areas or particularly large population growth leads to greater competition for the limited resources available. Such conflicts are by no means confined to tensions between regions but could also manifest themselves in internal conflicts within a particular part of society (for a more extensive treatment of the Nile basin conflict, see Link (for a more extensive treatment of the Nile basin conflict, see Link et al. 2010).

3.8.3 Model Framework for the Assessment of Conflict and Cooperation

Building on the setup shown in the scheme in Figure 3.13 and the VCAPS model framework for multi-agent conflict introduced in section 3.7, the interactions between water use and availability in the Nile basin and the impacts of climate change are reviewed. For the four major riparian countries (Egypt, Sudan, Ethiopia, Uganda), the options of each country for investing in water use and supply, either within their own national borders or in a neighboring country, are discussed. Additionally, countries can use their investments to threaten each other in order to prevent or enforce certain actions by the other country. A schematic representation of the interactions of the countries in the model is shown in Figure 3.14.

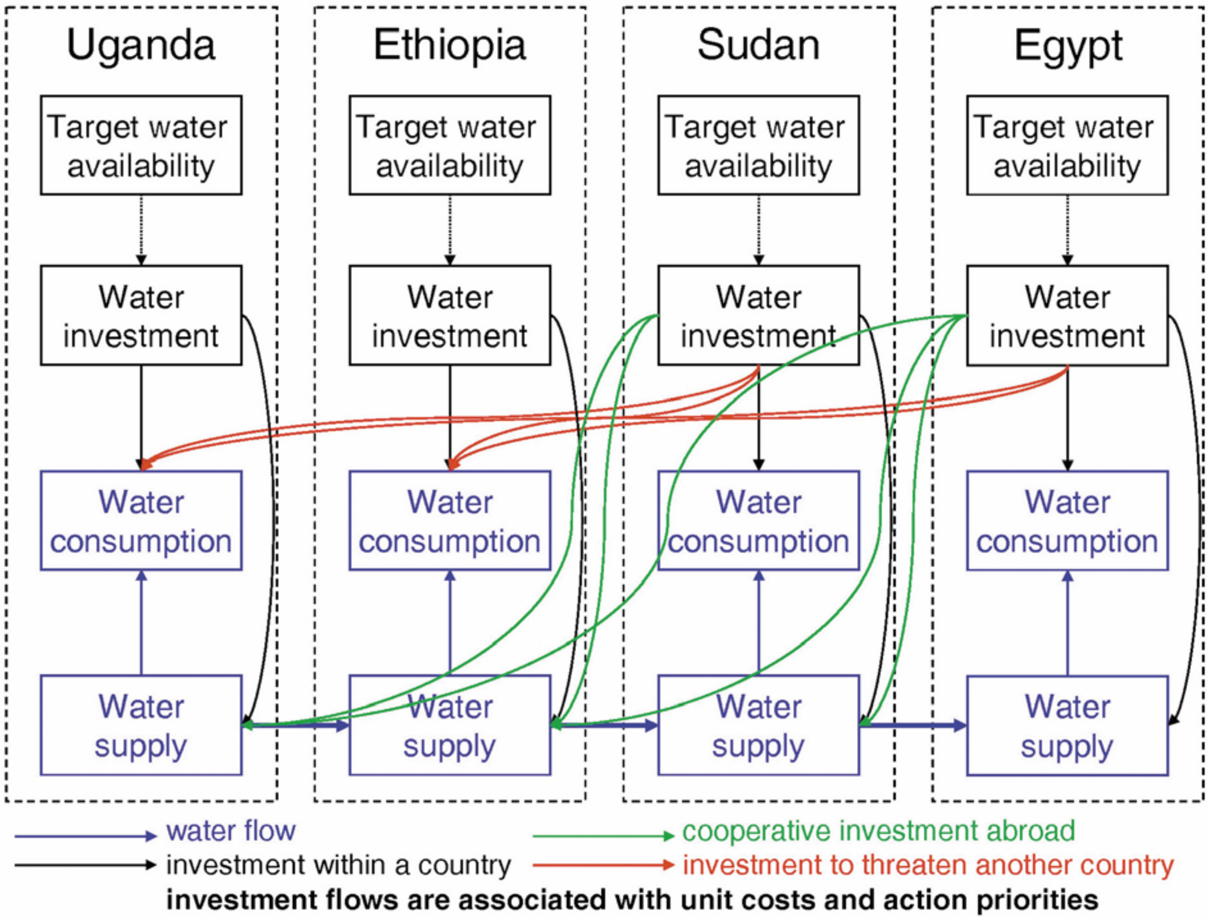

Figure 3.14 Interactions between four Nile basin countries in the simulation model (the authors)

Investments in water resources depend on a target water supply in each country. This target water supply is determined on the basis of a desired development in per capita water consumption and projections of overall population development. There is also a maximum amount that each country is willing to invest in the development of water resources. This maximum amount depends on the overall economic conditions as directly related to *gross domestic product* (GDP). The change in water use and supply not only depends on the total investments made, but also on the unit costs and the fractions (priorities) of investments allocated to each action path. Each country is assumed to invest in at least one of the following action paths:

1. national water consumption without exceeding actual water supply;
2. increase in national water supply;
3. collaboration on water supply with an upstream country in order to benefit from increased external supply;
4. threat to or pressure on an upstream country not to reduce the transboundary water supply by increased water consumption, or resistance to threats by a downstream country.

While the first two are unilateral measures, the third requires cooperation and the last drives conflict between countries. Total change in water availability is the result of water related investments by all countries (corresponding to the invested capability in the general model framework) and their associated impacts, which also determine how the countries interact. We assume that the countries pursue certain future targets to satisfy their water needs which serve as value goals. These result in the target investments (efforts) by each country that drive water availability, in order to pursue national water goals according to dynamic adaptation rules.[31] Water availability in each country is affected by that country's own allocation of investments to the action paths as well as by all other countries' investments. The actual allocations depend on the unit costs and allocation priorities for each action path. This interaction is represented by an adaptive dynamic system of difference equations with a temporal resolution of one year.[32] It describes the dynamic interaction of the riparian countries that adjust their investment levels and control the dynamics by the speed of their response and by their priorities. By allocating the investment shares to the alternative action paths, the countries can influence the direction of their response.

[31] Translating the problem into the VCAPS model framework, efforts ΔC are represented by water investments, value goals V^* are given by targets for water availability, and action paths A are the four investment paths given above. The term "availability" is used here to indicate the sum of water consumptions and supply. Action priorities p are the fractions of investment to each path which are adjusted according to decision rules as a function of unit costs c.

[32] While hydrological variability is shaped by seasonal developments, the unit of one year is chosen to reflect annual investment decisions.

3.8.4 Results of Model Simulations

In the simulation runs, each country starts with a typical initial Nile water consumption and supply. Then each country defines a target path for the change in water availability for a future period (in this case 20 years). This target path is based on population projections to satisfy the water needs of that population and on the development of per capita water consumption. It is assumed that each country is willing to apply a certain maximum investment in water availability, which is a given percentage of GDP that is not to be exceeded. Investments in water resources are initialized on the basis of actual water consumption in each country. They then adjust investment to the self-defined water availability within the investment limits, as described above.

The water unit costs for the different action paths are selected to represent a situation in which the unit costs for investing in increased water supply are considerably higher than the unit cost for water consumption, as long as the latter remains at a level below the water supply.

Domestic unit cost in Egypt is higher than in upstream countries, making it beneficial to also invest in upstream countries. Putting pressure on an upstream country has a low unit cost if the neighboring country gives in to this pressure, but has the highest unit costs if this country resists, either by counter-pressure or by taking other non cooperative action (including the possible use of force).

We analyze two scenarios of climate change, reflecting the wide projected climate variability (for more details see Link et al. 2010). In the first case, climate change reduces water supply in the Nile basin by 20 per cent by the end of the 20- year simulation period, in the second case there is an increase by 20 per cent over the same time.

Investment in acquiring additional water resources to satisfy the growing demand for water is generally initially highest when the water becomes scarcer, i.e. if there is a negative climate impact (Figure 3.15). Countries have to invest more money as there is less water naturally available to them. The particularly strong increase in investments in Egypt in the scenario with growing overall availability of water has to do with the fact that the intended expansion of water availability in this country leads to a rise in consumption costs within the increased supply limits.

Furthermore, the oscillations in Egyptian investment in new water resources can be attributed to the fact that the country experiences switches between periods in which its strategy of threatening upstream countries is resisted and others in which the pressure is accepted by the other country (Figure 3.15). Since investment costs are much higher in phases of resistance, this diminishes the incentive to threaten and increases incentives to cooperate, leading to a cyclic switch between phases of conflict and cooperation, as given by the boundary case shown in Figure 3.15. If the difference in costs between resistance and non resistance were larger than in the case shown, the countries would refrain from threatening their neighbors as the strategy becomes too costly in the long run.

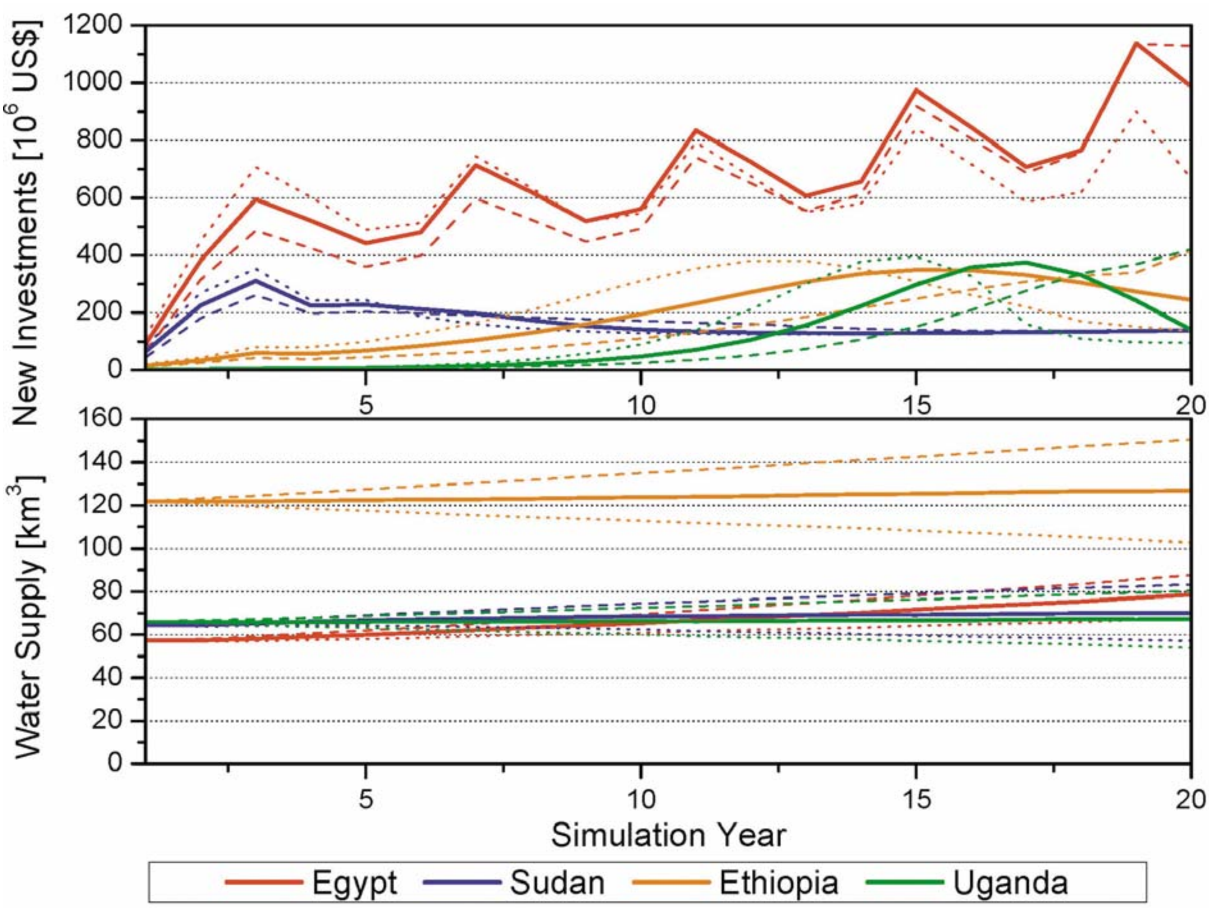

Figure 3.15 Development of investments in water supply (top) and the resulting water supply (bottom) in each country (the authors). The solid lines denote a reference scenario without climate change. Dashed lines denote the case of a climate-change-induced overall increase of water resources of 20 per cent by the end of the simulation period, the dotted line a decrease of 20 per cent

The development of the water supply in the countries considered in the model coincides with the climate scenarios. Without any climate change influence, there is only a slight expansion of water supplies as investments are made in new sources. However, this strategy is quite expensive. The climate change influence dwarves these efforts, as the supplies grow considerably if there is more water available naturally and shrinks much more than can be offset by investments if water becomes scarcer as a consequence of climate change. Due to water consumption goals considerably higher than initial consumption in the countries of the Nile river basin, fair amounts need to be invested. In Egypt water consumption is close to the supply level throughout the simulation period. Whether the strategies that are predominantly chosen are cooperative or conflictive depends on the relative unit costs involved in choosing the respective strategies. In our example, only Egypt has a relevant incentive to impose pressure on its neighbors, while the other countries usually fare best if they rely on investments in domestic infrastructure to improve their own consumption and supply levels.[33]

This model of water allocation decisions in the Nile basin in the context of climate change is a simplified first piece of a compulsory model of climate-society interaction in this region. It looks at only one aspect, albeit a very important one, that affects societal interaction in this watershed. Current model results may still be explained intuitively but non linear effects are likely to show up when more important features of societal interaction in this region are added. Despite the simplifications embodied in the specific simulation results, the analysis supports the notion that the hydro-hegemony status of Egypt is increasingly being challenged by upstream states who need water and hydropower for their own development and who question previous legal water arrangements that favor Egypt. Instead, they promote a new institutional setting that provides a new balance between upstream and downstream states that Egypt so far hesitates to accept. To address these challenges and to find a possible institutional framework for cooperative water management, a special security architecture in the North African – Middle Eastern – Mediterranean region can play an important role. Close cooperation between Europe and North Africa over water and food security, energy, and climate security can be beneficial for the entire region, can increase adaptive capacity, contribute to emission reduction especially in the power sector where North Africa can offer significant solar energy resources, and can create the preconditions for long-term stability (Brauch 2010).

[33] While some of these results could be achieved by qualitative considerations, the model simulation allows varying parameters and the determination of boundary conditions for a qualitative change of model behaviour, e.g. the transition between conflicting and cooperative behaviour by Egypt.

3.9 Discussion and Conclusions

In many ways, anthropogenic climate change may affect natural resources and human needs, posing a potential risk for human security and for the stability of societies in many parts of the world, e.g. by a rise in the number of weak states, increased risks for economic development, and international conflicts over resources. These interactions between different spheres of the climate-society relationship are complex and difficult to predict from historical data. Many of the sensitivities of the individual systems are ambiguous or difficult to quantify.

Particularly challenging is the adequate representation of human behavior using the assessment tools of climate-society interaction. On the macro level, game theory may be used to analyze interactions of limited complexity, while at the micro level multi-agent approaches can better describe processes of pattern formation among a large number of actors following particular rules of behavior. Consequently, phenomena such as path dependency and cascading effects are relevant in describing how large groups of individuals can influence the decisions of entire societies.

Despite these challenges, it is possible to devise a modeling framework that includes not just the fairly well-understood processes of climate change and its impacts on the natural environment. The framework presented in the previous sections of this chapter extends further to comprise also the realms of human wellbeing and societal stability. It can be shown how it is possible to obtain information on the stability of a given system in qualitative terms even if there are not enough underlying data available to completely solve a model setup numerically.

The last section of this chapter has introduced an application of the model framework to an expected future climate hot spot. Based on an assessment of the water related conflict between countries in the Nile river basin with their asymmetric capabilities and adaptive capacities, the way in which the impact of climate change on water availability and conflict constellations in this region could affect the behavior of key riparian countries towards each other has been discussed. In the multi-actor model, the countries invest in water supply and consumption to reach water development goals, depending on the unit costs of the action paths and a natural limit of water availability due to climate change. The analysis suggests that the countries compete for the Nile water by increased investment, with Egypt temporarily putting pressure on upstream countries, but that cooperation provides a strategy to achieve water goals at reduced cost. The application of the model framework is an example of the possibilities of simulation tools to expand understanding of climate-society interaction.

PART II NORTHERN AFRICA

4. Climate Change, Vulnerability and Adaptation in North Africa with Focus on Morocco[34]

Abstract

Our study links environmental impacts of climate change to major socio-economic and agricultural developments in North Africa. We jointly investigate climate projections, vulnerability, impacts, and options for adaptation. Precipitation in North Africa is likely to decrease between 10 and 20%, while temperatures are likely to rise between 2 and 3°C by 2050. This trend is most pronounced in the northwestern parts of northern Africa as our own model results suggest. The combination of decreasing supply and strong population growth aggravates the stressed water situation in the region. We further compare the vulnerabilities, adaptive capacities and conflict implications of climate change in Algeria, Egypt, Libya, Morocco, and Tunisia. Climate change will likely have the strongest effect on Morocco where the agricultural sector is of high importance for the country's economy and particularly for poor people. Our analysis of climate impacts and adaptation options in Morocco suggests that the agricultural incentives used in the past are inadequate to buffer drought effects. To increase resilience against climate change, agricultural policies should shift from maximizing agricultural output to stabilizing it. Our bio-economic model results further suggest a considerable potential of replacing firewood by electric energy to sustain pastoral productivity.

4.1 Introduction

Climate change poses a significant challenge for North Africa, affecting and interacting with both environmental and anthropogenic systems in the region. Among the variables of interest are environmental degradation, agricultural productivity, food security, population growth and economic and societal (in-)stability. So far, the

[34] This chapter has been published in the peer reviewed publication Schilling, Janpeter, Freier, Korbinian P., Hertig, Elke, Scheffran, Jürgen, 2012. Climate Change, Vulnerability and Adaptation in North Africa with Focus on Morocco. Agriculture, Ecosystems & Environment 156, 12-26. As the lead author, Janpeter Schilling is responsible for the majority of the chapter's content. Janpeter Schilling has contributed more than 50% to the introduction, more than 90% to the vulnerability section, about 40% to the section on Morocco and about 50% to the synthesis.

majority of research articles have focused on climate change and its interrelation with one or two of the aforementioned variables (e.g. Bekkoussa et al. 2008, Lhomme et al. 2009, Sowers et al. 2011, Thomas 2008).

The present article aims to draw a wider, although not exhaustive, picture of climatic and social changes in North Africa by integrating perspectives from climate science, social geography, conflict research, and environmental sciences. We jointly investigate some major interrelations between climate projections, vulnerability, impacts, policy responses and options for adaptation.

The starting point of our investigation is a description of the physical climate variability and climate change as presently observed and its projections for the 21st century. We address the uncertainties of projections and their consequences for extreme events using our own model runs as well as data from the literature (section 2).

Against this background, we give an overview of the vulnerability to climatic changes of the five North African states Algeria, Egypt, Libya, Morocco and Tunisia (see Figure 4.1). The overview servers two purposes: First, it allows us to discuss security concerns of climate change which have been raised even prior to the riots in Tunisia, Egypt and Libya in 2011 (Iglesias et al. 2010, Smith and Vivekananda 2009, WBGU 2008).

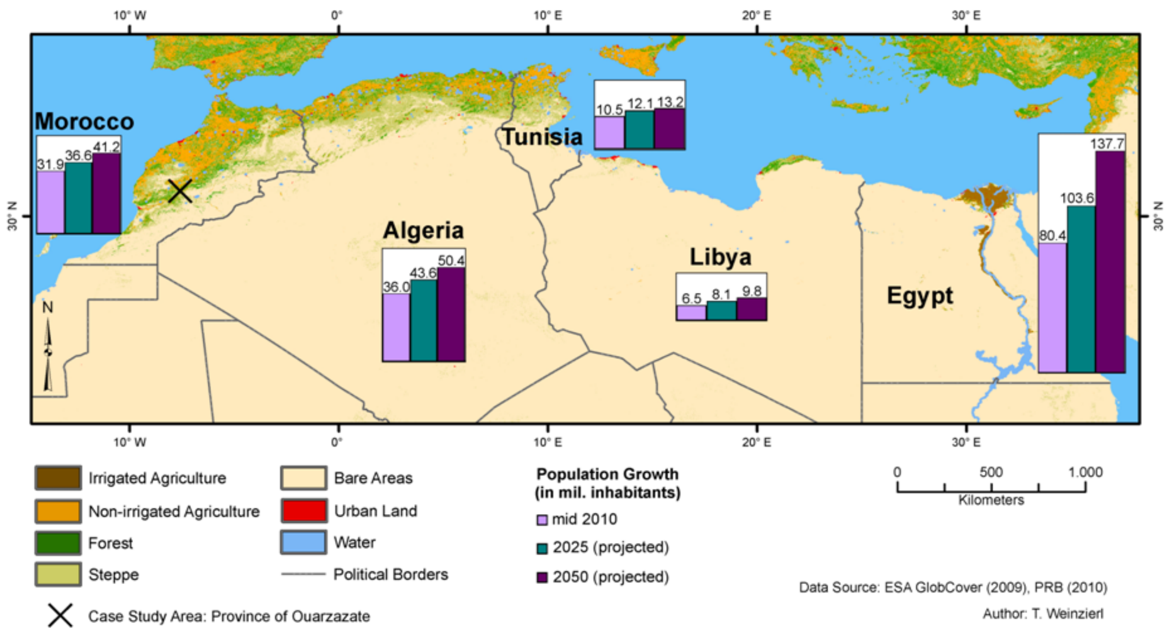

Figure 4.1 Land use and population growth in North Africa (own representation based on European Space Agency 2010, PRB 2010)

Second, the overview enables us to identify countries which are most vulnerable to climate change, in particular Morocco, predominantly because of its high sensitivity to climatic changes and its limited adaptive capacities (section 3).
Focusing on Morocco, we assess the impacts of climate change on agriculture and society which can be aggravated by unsustainable policy responses and agricultural practices. Based on this finding, we investigate a set of adaptation options using data from local research projects. In addition, a bio-economic model is used to explore the possibility of increasing resilience of pastoral livestock husbandry in semi-arid rangelands. One option is to replace firewood by other energy sources such as solar power (section 4). The insights from Morocco reveal linkages between climate change, agricultural practices and socio-economic developments which are also relevant for adaptation in other North African countries.

4.2 Climate Change in North Africa

4.2.1 Recent Climate Characteristics

Precipitation of North Africa is characterized by a wet season in winter and dry conditions in summer. The rainy season, which starts in October and lasts until April, has its maximum in the months from December to February (Endlicher 2000, Lionello et al. 2006). Additionally the whole region is characterized by high inter-annual precipitation variability. Thus, long-term mean precipitation, especially in the southern region of North Africa, reflects averages over many dry years and some relatively humid years.
A generalized overview of historical trends in the recent past and likely future trends under enhanced greenhouse warming conditions for temperature and precipitation in the North African countries is given in Table 4.1. For northeastern Morocco and northwestern Algeria, several studies point to below average annual rainfall rates which have prevailed since about the mid-1970s (Fink et al. 2010, Hertig 2004, Meddi et al. 2010). Also for the southern parts of the Moroccan Atlantic coast as well as for the Atlas Mountains several periods of below average precipitation occurred in the second half of the 20th century in the winter season, for example in the period 1971 to 1975 and in the period 1979 to 1983, but also some positive anomalies can be found around the late 1980s and 1990s (Hertig 2004). Due to the observed changes, a general tendency towards warmer and drier conditions can be found in

the last decades for the above mentioned regions (Born et al. 2008, Gerstengarbe and Werner 2007). In contrast to the predominantly negative precipitation evolution in the western parts of northern Africa, no pronounced precipitation trends have been observed for the eastern regions such as northeastern Algeria (Meddi and Talia 2008), Mediterranean Tunisia (Hertig 2004), central Tunisia (with some decadal variability, Kingumbi et al. 2005), and the Mediterranean parts of Libya and Egypt (Hertig 2004) during the last decades of the 20th century.

Table 4.1 Generalized overview of recent and likely future trends of temperature and precipitation in North Africa (sources see text)

State	Recent trends		Future trends	
	temperature	precipitation	temperature	precipitation
Algeria	+	-	+	-
Egypt	+	o	+	-
Libya	+	o	+	-
Morocco	+	-	+	-
Tunisia	+	o	+	-

\+ increase - decrease o no change

Born et al. (2010) find that the skill of simple statistical seasonal rainfall predictions is limited. Using multivariate statistical analyses, Hertig and Jacobeit (2010b, a) show that precipitation in February in the Atlas Mountains of Morocco, regional temperatures in Algeria and Tunisia in the month of May, and December temperatures in the western parts of northern Africa can be predicted by taking preceding sea surface temperature anomalies as predictors. Thus, it becomes evident that there is some skill regarding seasonal predictions of temperature and precipitation (see Slimani et al. 2007 for Tunisia). In the scope of possible future enhancements of such predictions, they could become more important, especially in the context of the additional challenges due to climate change.

4.2.2 Future Climate Change

For northern Africa climate change studies indicate that annual precipitation is likely to decrease during the course of the 21st century (Gibelin and Déqué 2003, Giorgi and Bi 2005, Rowell 2005). According to the Regional Model REMO, precipitation in North Africa is likely to decrease between 10% and 20% until the year 2050 under SRES A1B scenario conditions (Paeth et al. 2009). For winter precipitation, decreases are modelled by Räisänen et al. (2004), with strongest reductions in the Moroccan region. An assessment of precipitation changes within the IMPETUS project shows that Moroccan rainfall might be reduced in the period 2011-2050 between 5% (mountainous areas) and 30% in the southern regions for the SRES A1B scenario and by 5% and 20% for the B1 scenario (Christoph et al. 2010). Projected precipitation decreases in winter are controlled by processes which involve a systematic shift of the cyclone tracks to a more poleward position. This leads to drier conditions in North Africa (Knippertz et al. 2003). In summer a positive feedback with decreased soil moisture values have to be considered. Feedback mechanisms which can be attributed to increased soil drying can already be observed (Fink et al. 2004). However, it has to be kept in mind that the exact spatial location of the polar front in a future warmer climate is still highly uncertain. Furthermore atmospheric humidity has to be taken into account because of the increased moisture holding capacity of the atmosphere under warmer conditions.

Precipitation

Statistical downscaling of precipitation for a region covering the western parts of northern Africa shows rainfall increases in December/January of up to about 60 mm in the period 2071-2100 compared to the time period 1990-2019 (Figure 4.2). The results are based on assessments of precipitation changes under the SRES B2 scenario assumptions using a statistical downscaling technique (canonical correlation analysis). The SRES B2 scenario was chosen because it is based on developments which are visible today. These include a continuously increasing global population, intermediate levels of economic development, a relatively diverse technological change, and an orientation towards environmental protection on local and regional instead of global levels (Nakicenovic and Swart 2000). The level of greenhouse gas emissions, expected under the B2 scenario, provides a suitable medium compared to the very high and very low SRES scenarios. For the downscaling, 1000 hPa/500 hPa geopotential heights (representing the atmospheric circulation in the lower and middle troposphere) and 1000 hPa specific humidity (typifying atmospheric moisture conditions) were taken as large-scale predictors. A detailed description of the downscaling technique can be found in Hertig and Jacobeit (2008b). As can be seen from Figure 4.2, there are negative precipitation changes at the beginning of the rainy season in October/November. However, in high winter (December/January) substantial increases are estimated. This could be attributed to changing circulation patterns (e.g. to a more southerly path of storm tracks in connection with a pressure rise centered over Central Europe in December and January as simulated by some coupled global general circulation models, see Hertig 2004). In this context, enhanced atmospheric humidity can be regarded as an additional factor for higher rainfall amounts. A simulation with a local model within the IMPETUS project shows more intense precipitation events south of the Atlas Mountains as a result of enhanced humidity advection (Christoph et al. 2010). In summary it should be noted that also decreases of precipitation in winter are projected for Mediterranean North Africa, for example by Giorgi and Lionello (2008) under the use of an ensemble of global circulation model simulations (GCMs) and by Paeth et al. (2009) by means of dynamical downscaling. In the statistical assessment of the present paper, weak increases continue in some sub-areas in February/March (Figure 4.2).

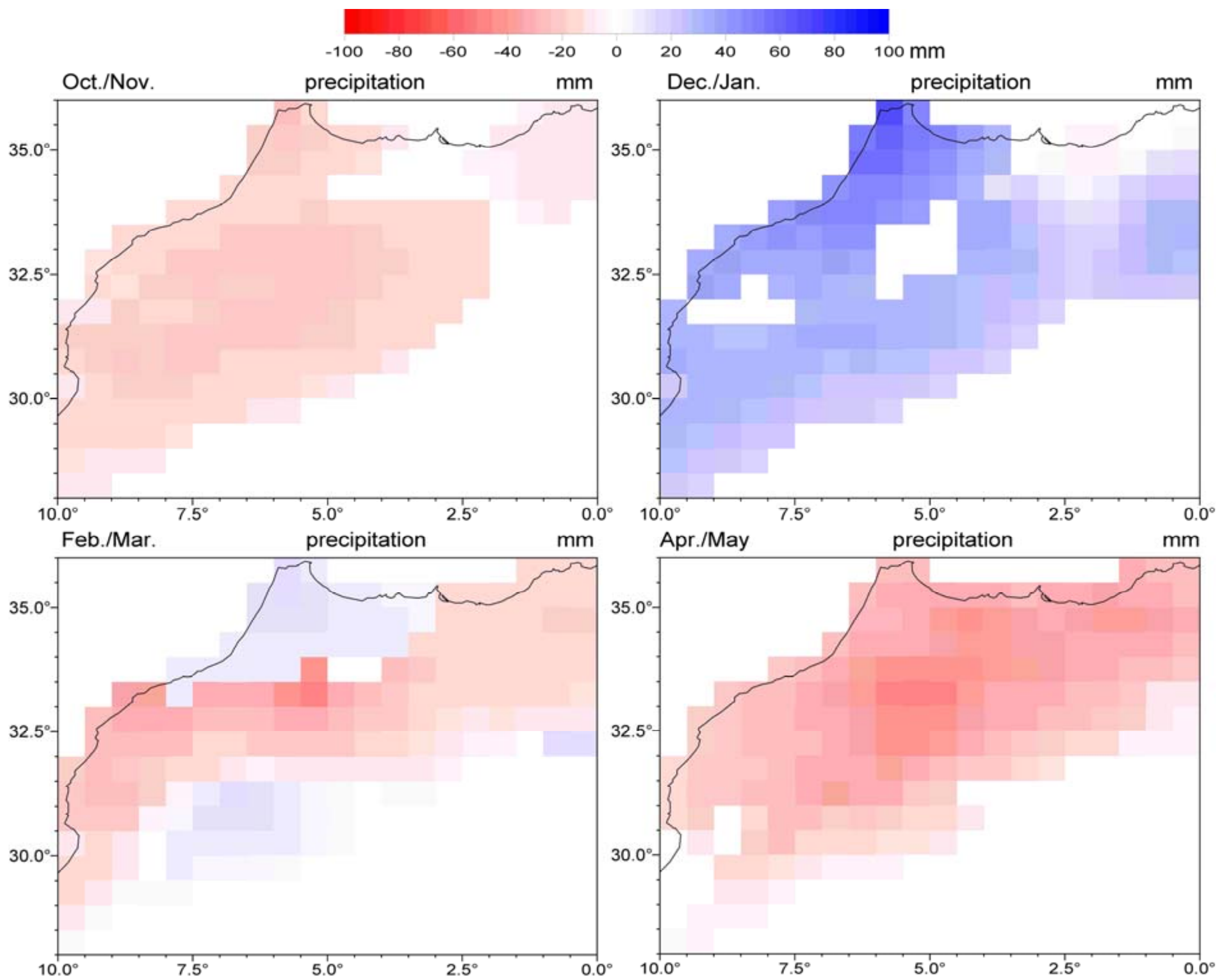

Figure 4.2 Changes of Mediterranean precipitation for the main rainy season from October to May according to statistical downscaling assessments using ECHAM4/OPYC3 predictors (1000hPa-/500hPa- geopotential heights and 1000hPa-specific humidity). Differences of the mean 2-month precipitation between the periods 2071-2100 and 1990-2019 in mm. Statistical downscaling technique: Canonical Correlation Analysis. Scenario: SRES-B2

Thereafter, the whole region is affected by drier conditions in spring (April/May). The signal-to-noise-ratio (the rainfall difference of the two 30-year periods in relation to natural variability) of the precipitation reduction in spring is greater than one, indicating that the climate change signal is greater than the recent natural variability. A study by Palutikof and Wigley (1996) also estimates decreased rainfall south of the Mediterranean Sea during spring. Around this drier region, the northwestern parts of northern Africa stand out as a region of most pronounced decreases in precipitation. This was also reported by Jacobeit (1994). Summarizing the results of the statistical downscaling, a shortening and at the same time an increase in rainfall amount of the wet season arises for the western parts of North Africa.

Temperature

Regarding temperature the dynamical regional model REMO suggests a temperature rise in North Africa between 2 and 3°C by 2050 under A1B scenario conditions (Paeth et al. 2009). The temperature rise for Morocco is estimated to 1.2°C in the SRES A1B and 1°C in the B1 scenario. Both scenarios yield a slightly more pronounced increase in the mountain region (Christoph et al. 2010). An application of regional and global climate models by Patricola and Cook (2010) for northern Africa shows a very strong warming of about 6°C over northwestern Africa in the 21st century compared to the 20th century. Also, when looking at results from statistical downscaling by Hertig and Jacobeit (2008a), a temperature rise becomes visible for western North Africa. The temperature assessment indicates increases of mean temperature in all months of the year, with largest warming rates in summer (June/July) and autumn (Oct./Nov.) of partly more than 4°C until the end of the 21st century. The lowest warming rate is assessed for the winter months December and January with values of up to about 1°C. Overall the spatial warming pattern has an emphasis on the mountainous areas of the Atlas Mountains, and weakens towards the coastal areas of the Atlantic Ocean and the Mediterranean Sea.

Extreme Events

Concerning extremes, more precisely droughts, the risk of these events is likely to increase in northern Africa (WBGU 2008). For Europe and western North Africa Räisänen et al. (2004) find that average precipitation reduction is associated with a reduced number of precipitation days rather than with reduced precipitation intensity. Voss et al. (2002) determine a significant prolongation of very long dry spells (10-year return values of annual maximum dry spells) in the period 2060-89 compared to 1970–99 for northern Africa. In a study using observational data and the regional climate model REMO Born et al. (2008) find a trend to shorter return times of stronger dry periods in the observed climate and a continuation of this trend in climate scenarios under greenhouse gas forcing. A study of Beniston et al. (2007) also indicates considerable drying over western Mediterranean North Africa. The main features are reduced intensity of precipitation, and earlier onset and longer duration of drought (i.e. continuous period of days with no precipitation). This finding is in accordance with the study of Tebaldi et al. (2006) who also find a significant increase in dry days (defined as the annual maximum number of consecutive dry days).

Uncertainties

As the previous discussion already suggests, projections of future climate change for Africa exhibit considerable uncertainties. The IPCC concludes that it is necessary to improve the assessments for most of the African regions. The GCMs still have major difficulties over Africa, for example unrealistic climate variability in the Sahel zone or a southward displacement of the Atlantic inter-tropical convergence zone (Christensen et al. 2007). In some projections the greening of the Sahara is a possibility (see Claussen et al. 2003). GCMs show a range of performance in simulating the climate in the Mediterranean parts of North Africa. Thus temperature biases range from –5°C to 6°C, depending on model and season, but the modelled area and ensemble mean precipitation is found to be close to observations (Christensen et al. 2007).

Apart from the fact that climate models are the only possibility to assess future climate change, it must be emphasized that major uncertainties are still inherent in GCMs. Those are associated with the spatial and temporal resolution, the corresponding issue of discretization and parameterization, the reproduction of sea surface temperatures, soil moisture, the account for stratospheric processes, and especially the problems of unknown initial conditions of corresponding variables (Hertig et al. 2012). Dynamical and statistical downscaling assessments also need major improvements for the North African domain. For instance it is necessary to gain a better understanding of climate variability in this region, which involves the inclusion of specific feedback mechanisms for example of the oceans and of land use change. In recent years more attention has been turned to this region as for example by the IMPETUS project or the CORDEX (Coordinated Regional Climate Downscaling Experiment) initiative, which tries to enhance regional climate change information especially for the Mediterranean area and Africa.

4.3 Vulnerability of North Africa

This section gives an overview of the vulnerability to climate change of the five North African states, Algeria, Egypt, Libya, Morocco and Tunisia. So far, the concept of vulnerability lacks one generally accepted and precise definition (e.g. Füssel 2007). Yet, three elements of vulnerability can be identified as consistent throughout the literature: i) exposure to climate change, ii) sensitivity to climate change, and iii) adaptive capacity (Adger 2006, IPCC 2007a, Smit and Wandel 2006). Exposure to climate change has been described in the previous section; sensitivity and adaptive capacity are subject of this section.

With respect to the overview character of this section, the discussion of sensitivity focuses on agriculture which is most directly affected by climate change (Mougou et al. 2011). The indicators used to analyze the sensitivity and the adaptive capacity were chosen based on recognition in the literature, consistency and availability. The resulting catalogue of indicators is similar to the one suggested by Brooks et al. (2005). In 3.3 the findings on sensitivity (3.1) and adaptive capacity (3.2) are combined with the climate change exposure (section 2) to assess the vulnerability and to draw conclusions for potential conflict implications.

4.3.1 Sensitivity

While closely related to exposure, sensitivity is “the degree to which a system is affected, either adversely or beneficially, by climate variability or change” (IPCC 2007a:881). In the context of this paper we focus on the resource dimension of sensitivity as suggested by Barnett and Adger (2007). The following section therefore discusses the availability of the affected resources prior to the climate stimuli and the importance of the resource for the system.

Water Availability

Depending on the index used, the North African countries are either termed stressed or scarce. According to the Hydrological Water Stress Index (HWSI) Algeria and Tunisia face the highest level of water scarcity while in Egypt and Morocco water is less scarce (Figure 4.3)[35].

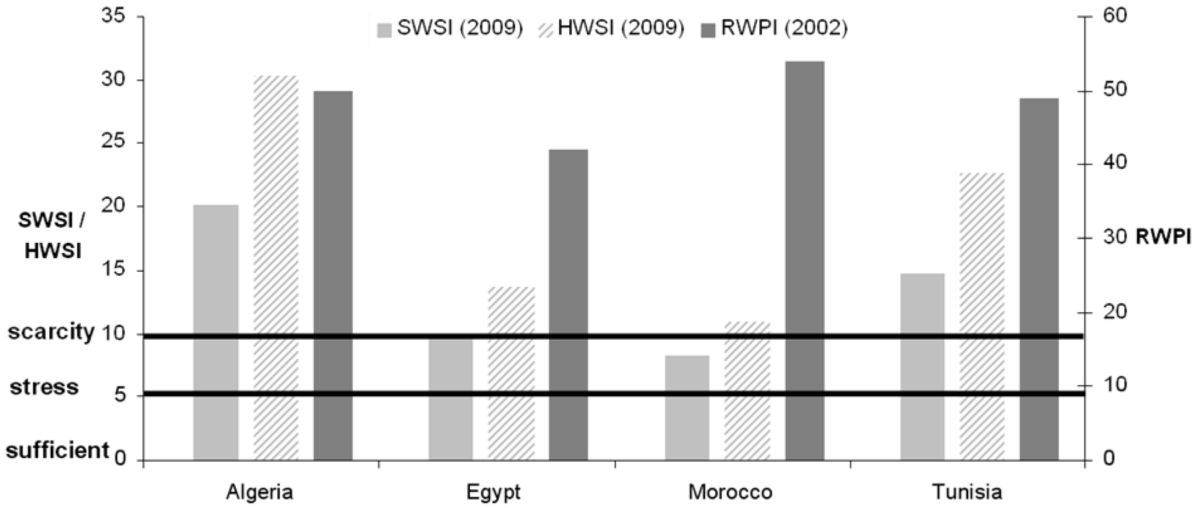

Figure 4.3 Comparison of water indices for North Africa (own calculations based on FAO 2010a, Ohlsson 2000, World Resources Institute 2008). The HWSI (Hydrological Water Stress Index) measures the number of hundreds of people per one million m³ of available renewable water. The Social Water Scarcity Index (SWSI) equals the HWSI divided by the human development index (HDI) (see Table 4.4) and by a correction factor of 2 (Ohlsson 2000). A SWSI or HWSI of 0 to 5 indicates sufficient water supply, a value above 5 and below 10 indicates water stress and values above 10 indicate water scarcity (see black lines). The Water Poverty Index (WPI) measures the impact of water scarcity and water provision on human populations (World Resources Institute 2008). Its values lie between 0 and 100. High scores indicate a higher water provision. For the purpose of graphical representation the WPI has been reversed to the RWPI (Reversed Water Poverty Index) by subtracting the value for the WRI from 100. Hence, for the RWPI higher values indicate lower water provision. The categories (sufficient, stress and scarcity) only apply to the SWSI and the HWSI

If the human development is taken into account the situation seems to be less dramatic (see SWSI in Figure 4.3). The Social Water Scarcity Index (SWSI) indicates water stress in Egypt and Morocco and water scarcity in the remaining countries. Although the SWSI to some extent takes the social adaptive capacity of the affected society into account (see following sections), it does not say anything about other relevant factors such as the distribution or the quality of the water. In this respect, the Water Poverty Index (WPI) is more suitable as it is composed out of four indices on:

[35] Libya has by far the lowest renewable water resources; 60 million m³ compared to the second lowest, Morocco with 4.6 billion m³ in 2008 (FAO 2010a). This causes its water indices (HWSI of 1050 and SWSI of 797) to lie way out of range. Additionally no water poverty index was available. Therefore Libya is excluded from the discussion of water indices.

water resources, access, capacity and environment (see Lawrence et al. 2003). Even though the WPI should be seen as an "order-of-magnitude estimate" (World Resources Institute 2008:213), it still partially reverses the statement of previously discussed indices. While both the HWSI and the SWSI characterize the water situation in Morocco to be comparatively less serious, the country is the water poorest according to the WPI (see Reversed Water Poverty Index (RWPI) in Figure 4.3).

Aside from the country specifics on the water supply side, all states share one common development on the demand side: significant population growth. Egypt is expected to see the strongest growth with an increase of 57 million people until 2050 (Figure 4.1). Algeria and Morocco could grow by more than 14 and 10 millions, respectively. The population growth of the smaller states Libya and Tunisia is also significant, especially in relative terms. Both the relative and absolute population growth will increase the demand for food and water on the national and regional scale. Interlinked with this development are the processes of urbanization and littoralization (concentration of population along the coast) which could lead to highly localized peaks in water and food demand.

Agricultural Sector

The agricultural sector is in all North African countries by far the largest consumer of water, mostly reaching values above 80% (Table 4.2). It is therefore promising to look into the agricultural sector and its importance for each country in more detail.

Except from Egypt's agricultural sector which is focused on the Nile, all other countries in North Africa depend almost entirely on precipitation as the main water source for agriculture (see Table 4.2 and Figure 4.1). The dependence on precipitation determines the impact of climate change on agricultural productivity. While the agricultural productivity can be increased under climate change conditions in Egypt, a decrease in productivity of almost 30% is projected for Algeria and Morocco, even if the use of carbon fertilization is considered (Cline 2007 and Table 4.2). Without carbon fertilization the climate change impact increases by 10% (see also Lhomme et al. 2009, Mougou et al. 2011). The IPCC (2007a) estimates that in North Africa climate change will cause a loss in agriculture of between 0.4 and 1.3% of GDP by 2100.

Table 4.2 Agriculture and climate change impact in North Africa (Cline 2007, FAO 2010a, b)

State	Percentage of water withdrawals used for agricultural purposes (2000)	Rain fed land as a percent of total agricultural area (2003)	Percent impact of climate change on agricultural productivity by 2080 (compared to 2003), without carbon fertilization	Percent impact of climate change on agricultural productivity by 2080 (compared to 2003), with carbon fertilization
Algeria	65	98.6	-36	-26.4
Egypt	86	0.1	11.3	28
Libya	83	97	NA	NA
Morocco	87	95.2	-39	-29.9
Tunisia	82	96	NA	NA

The importance of the agricultural sector for the economy varies strongly among the considered states. Table 4.3 shows the sectoral composition of GDP and labor force in North Africa. In Algeria and Libya the industry contributes most to the GDP, while in Egypt, Morocco and Tunisia the service sector is most important. Agriculture is in none of the countries the largest contributor to GDP. However, in Morocco the agricultural sector, reaching 17%, is significant for the GDP. This becomes even more evident when the occupational distribution across sectors is considered. Almost half of the working population in Morocco is employed in the agricultural sector (Table 4.3). Considering both GDP and employment, the importance of the agricultural sector in North Africa ranges from medium (Libya, Algeria) to high (Tunisia) and very high (Morocco, Egypt).

Table 4.3 Sectoral composition of GDP and labor force in North Africa (CIA 2010)

	GDP (est. 2010)			Labor force (est.)		
State	Agriculture percentage	Industry percentage	Services percentage	Agriculture percentage	Industry percentage	Services percentage
Algeria	**8.3**	61.5	30.2	**14** (2003)	13.4	NA
Egypt	**13.5**	37.9	48.6	**32** (2001)	17	51
Libya	**2.6**	63.8	33.6	**17** (2004)	23	59
Morocco	**17.1**	31.6	51.4	**44.6** (2006)	19.8	35.5
Tunisia	**10.6**	34.6	54.8	**18.3** (2009)	31.9	49.8

In summary, depending on the index used, the water situation is most severe in Libya and Algeria (physical water availability) or in Morocco (water poverty index). The dependency on water and its importance for the economy is highest in Morocco, making the country overall the most sensitive to climate change.

4.3.2 Adaptive Capacity

According to the IPCC, the adaptive capacity of a society can be divided into generic and impact specific indicators. “Generic indicators include factors such as education, income and health. Indicators specific to a particular impact, such as drought or floods, may relate to institutions, knowledge and technology” (IPCC 2007a:727). Using indicators suggested by the IPCC and Adger (2006), this section compares the generic and impact specific adaptive capacities of the North African countries.

Generic Adaptive Capacity

The absolute economic resources are largest in Egypt, followed by Algeria and the significantly weaker economies of Libya, Morocco and Tunisia (Table 4.4). When measured in per capita income as suggested by Adger (2006), the distribution of the economic power changes. Here, Libya ranks highest and Morocco lowest. For the adaptive capacity of a society, it is important to consider not only the per capita income level but also its distribution across households. The highest levels of income inequality are found in Morocco and Tunisia (see Gini index in Table 4.4). According to the human development index Morocco shows the largest development deficit (Table 4.4).

Table 4.4 Generic indicators 1: Income and human development in North Africa undp (UNDP 2009)

State	GDP[1] in billion PPP[2] USD (2009 est.)	GDP per capita in PPP USD (2007)	GINI index[3] (average 1991-2007)	HDI[4] (2007)
Algeria	239.6	7740	35.3	0.754
Egypt	471.2	5329	32.1	0.703
Libya	95.88	14364	N/A	0.847
Morocco	91.84	4108	40.9	0.654
Tunisia	84.04	7520	40.8	0.769

[1] GDP: gross domestic product, [2] PPP: purchasing power parity, [3] the Gini index lies between 0 and 100. A value of 0 means absolute equality and 100 absolute inequality. [4] HDI: Human development index

The health level of the North African countries lies above the continent's average and below the European level (WHO 2010). While the under-five mortality rate of Algeria and Morocco is comparably high among the considered countries (Table 4.5), it is still low compared to the average value of 78 for the countries of the eastern Mediterranean region (for a complete list of countries see WHO 2010:176). Further, the percentage of undernourished population has not been critical over the past 20 years (FAO 2010b). More than 90% of the rural population of the considered countries use improved drinking-water sources, except for Morocco where this share only accounts for 60% (Table 4.5).

Table 4.5 Generic indicators 2: Health and education in North Africa (UNDP 2009, WHO 2010)

State	Under-five mortality rate (2008)[1]	Percentage of rural population using improved drinking-water sources (2008)	Education index (2007)[2]
Algeria	37	97	0.748
Egypt	23	98	0.697
Libya	17	NA	0.898
Morocco	36	60	0.574
Tunisia	21	94	0.772

[1] probability of dying by age 5 per 1000 live births, [2] the education index combines adult literacy rates and gross enrolment ratios

Overall, Morocco can be considered to have the lowest generic adaptive capacity as the country performs poorest in economic resources, human development, health and education. Prior to the outbreak of the war in 2011, Libya had the highest generic adaptive capacity in North Africa.

Impact Specific Adaptive Capacity

The adaptive capacity, specific to an impact, is shaped by the performance of institutions and the availability of knowledge and technology. With respect to the performance of institutions and the region's overall development, the level of corruption has been identified as a fundamental challenge which limits the efficient use of economic assets (see previous section) to moderate effects of climate change (Transparency International 2011). None of the countries reaches the threshold score of 5 on the Corruption Perceptions Index scale (ranging from 0, extremely corrupt, to 10, very clean, Table 4.6). Despite the corruption, the region has comparatively well developed regulatory and organizational capacities (World Bank 2007). However, the institutional setup has not yet led to significant water efficiency, conservation, or user participation (ibid). Further, institutional prioritization of adaptation measures is still lacking (Sowers et al. 2011). The knowledge index suggested by the World Bank "measures a country's ability to generate, adopt and diffuse knowledge" (World Bank 2009). As the index is composed out of different indicators on education, human resources, innovation, and information and communication technology, it interlinks with other impact specific and generic indicators (see previous section).

Table 4.6 Impact specific indicators: Corruption, knowledge and technology in North Africa (Schwab 2010, Transparency International 2010, World Bank 2010)

State	Corruption perceptions index (2009) [1]	Knowledge index (2009) [2]	Technological readiness index (2010)
Algeria	2.8	3.57 *	3.0
Egypt	2.8	4.24	3.3
Libya	2.5	N/A	2.9
Morocco	3.3	3.35	3.5
Tunisia	4.2	4.54	3.9

[1] the corruption perception index measures the perceived level of public-sector corruption. It is a "survey of surveys", based on 13 different expert and business surveys [2] the knowledge index is composed out of key variables on education, innovation, and communication technology, * incomplete data

Further, the index does not take indigenous knowledge into account which has been identified by other studies to be critical with respect to climate change adaptation (e.g. Ensor and Berger 2009). Still, the index allows for a general classification. In all five North African countries, the level of knowledge is lower than the MENA average of 5.68 but significantly higher than the continent's average of 2.72 (World Bank 2009 and Table 4.6).

Closely interlinked with the level of knowledge is the level of technology. Based on the Technological Readiness index, Tunisia is the most advanced country while Libya marks the lower end (Table 4.6). The index combines several components such as foreign direct investments, availability of latest technologies and number of internet users. As the predictive skill of seasonal forecasts may continue to grow (Section 2), the availability of technology is particularly important to communicate information to farmers and pastoralists.

In general, the impact specific adaptive capacity of a country is more difficult to characterize than the generic adaptive capacity. This is mainly because institutions, knowledge and technology are broader categories than the ones used to define the general adaptive capacity. However, Tunisia scores best in all three categories (corruption, knowledge and technology). Morocco performs relatively well in terms of corruption and technology, whereas Libya shows the lowest values in these categories.

4.3.3 Comparison and Conflict Implications

Figure 4.4 visualizes the three elements of vulnerability in a joint manner, combining

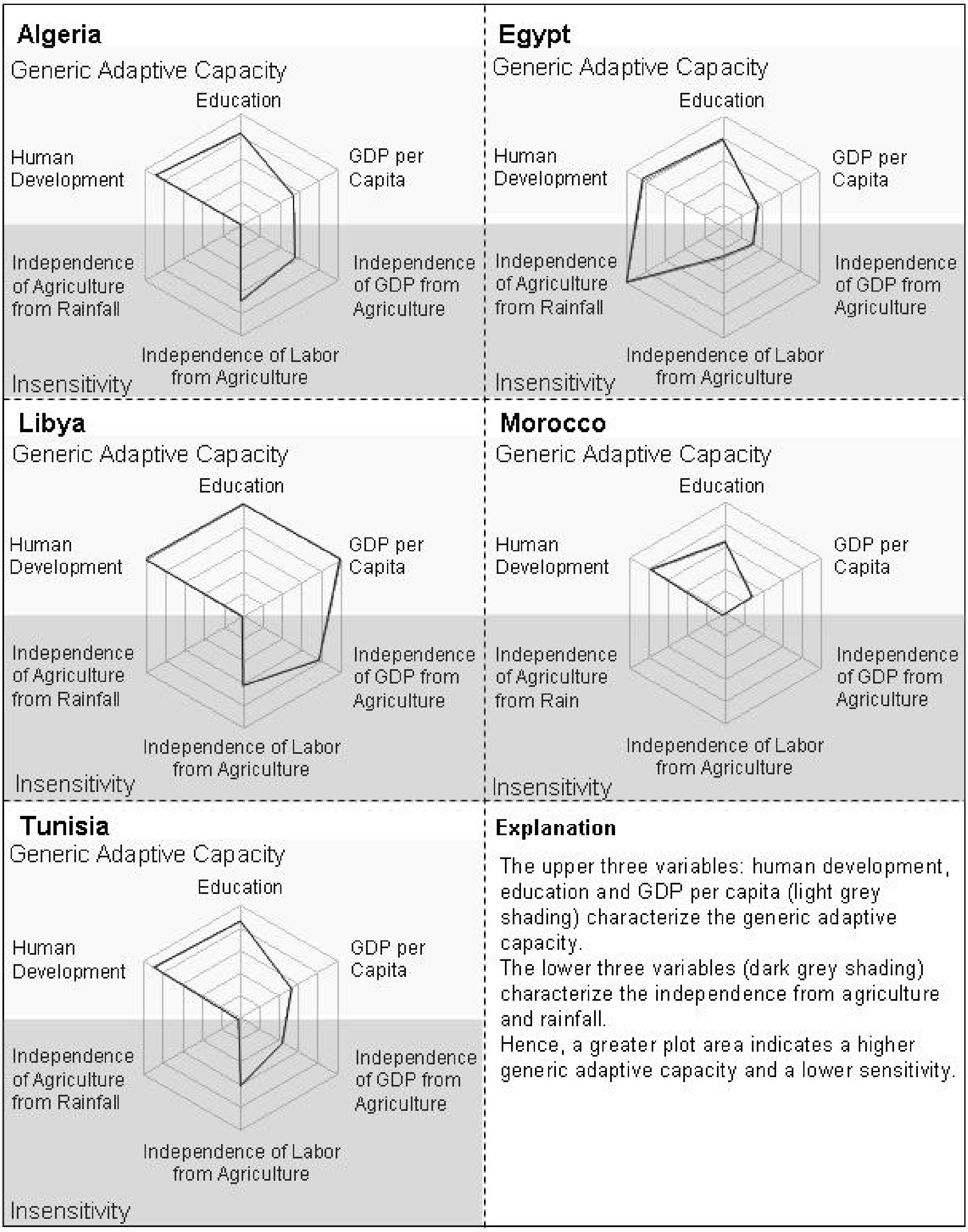

Figure 4.4 Generic adaptive capacity and insensitivity to climate change in North Africa (own calculations based on CIA 2010, FAO 2010b, UNDP 2009 see also values in Table 4.2 through 4.5). For the upper three variables (human development, education and GDP per capita) the highest value in North Africa is set 100 and the other country values are calculated accordingly. The lower three variables (related to agriculture) are taken from Table 4.2 and 4.3 and reversed for graphical representation

main indicators for the generic adaptive capacity (light grey shading) with main indicators for sensitivity (darker grey shading).[36] The figure relates the individual values of each country to the highest and lowest observed in North Africa. For reasons of graphical representation, the indicators representing the sensitivity towards climate change have been reversed to insensitivity. A greater plot area therefore indicates a higher generic adaptive capacity and a lower sensitivity, and hence, a higher resilience to climatic impacts.

Comparing the countries' plots, a general weakness of the region is its high dependency on rain fed agriculture, which can be observed in all countries but Egypt. In Egypt the importance of agriculture for employment and GDP as well as the low per capita GDP are most critical. Algeria and Tunisia show a similar distribution of generic adaptive capacity and sensitivity. Their greatest strengths are the level of education and human development. These categories were best developed in Libya but they have suffered from the violent conflict in 2011. Morocco has the smallest plot area, showing that it is the country with the lowest generic adaptive capacity and the highest sensitivity while the impact specific adaptive capacity is relatively better developed (see 3.2). However, the combination of high climate exposure, low generic adaptive capacity and high sensitivity makes Morocco the most vulnerable state in a vulnerable region (see also Yohe et al. 2006a).

Conflict Implications

Against the background of high vulnerability, increasing demand for food and water (driven by population growth) and the projected decline in agricultural productivity (driven by climate change), concerns have been raised about food and water security and its implications for conflict (e.g. Scheffran et al. 2012b). Iglesias et al. (2010:165) see a “potential for more pronounced water conflicts of neighboring countries” in North Africa. Smith and Vivekananda (2007:19) find a “high risk of political instability as a knock-on consequence of climate change” for Egypt, Libya and Morocco after assessing the factors of conflict, poverty, inequality, and governance. While a high risk of armed conflict due to climate change is expected for Algeria (ibid.), no risk was identified for Tunisia.

[36] The impact specific adaptive capacity is not included because of its limitations discussed in 3.2. The water situation is not shown, since it is already displayed in Figure 3.

Homer-Dixon's environmental scarcity theory (Homer-Dixon 1999) claims that environmental change likely leads to violent conflict when it is combined with population growth and unequal resource distribution. While our previous discussion has shown that water scarcity and population growth are characteristics of North Africa (see Figure 4.1 and 4.3), unequal resource distribution is more difficult to capture.

In the context of environmental conflict theory, Morocco seems to be particularly susceptible for conflicts related to environmental changes. Compared to the other North African countries, Morocco is also closest to meeting the criterion of low per capita income (see Table 4.1), which is often seen as a key factor for violent conflict (Collier 2007). According to Collier (2007) countries, which have experienced violent conflicts before, face a significantly higher risk of violence, especially within a 5 year post-conflict phase. In this regard Algeria, Egypt and most recently Libya are more conflict prone as they have experienced more conflicts in the recent two decades (Table 4.7). The application of Homer-Dixon's and Collier's conflict framework should not be misinterpreted as a simplification of the climate-conflict complex. Indeed, there are more factors such as ethnic diversity and political marginalization (for Morocco see Rössler et al. 2010) that potentially contribute to conflict. However, the discussion of population growth, unequal resource distribution, per capita income and conflict history is a first attempt to assess the conflict sensitivity of a country.

Table 4.7 Armed conflicts in North Africa between 1998 and 2008 (PRIO 2009b)

State	Number of conflicts 1989-2008	Dominant conflict intensity	Dominant conflict type
Algeria	18	minor armed conflicts and war	Internal armed conflict
Egypt	6	minor armed conflicts	Internal armed conflict
Libya	0		
Morocco	1	minor armed conflicts	Internal armed conflict
Tunisia	0		

Peace Research Institute Oslo (PRIO) uses the UCDP (Uppsala Conflict Database Program) definition of armed conflict: "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths" (PRIO 2009a:1). An "internal armed conflict occurs between the government of a state and one or more internal opposition group(s) without intervention from other states" (ibid.). A conflict of minor intensity has between 25 and 999 battle-related deaths in a given year (PRIO 2009a:7). Above this threshold a conflict is classified as "war" (ibid.)

In general, the assessment of potential conflict implications of climate change is a difficult task since there is neither a direct measurement of the resource distribution nor of small scale violent events (which would for instance capture food riots). PRIO's definition of conflict for example requires at least 25 battle-related deaths and the state as one conflict party (see Table 4.7). These criteria exclude lower levels of violence as well as conflicts where the state is not directly involved. Nevertheless the use of Homer-Dixon's environmental scarcity theory and Collier's conflict factors point to Morocco (unequal income distribution, high water poverty, comparatively low per capita income) and Algeria as well as Egypt (both high number of past conflicts, strong population growth) to being suitable for a more comprehensive analysis. Yet, Mougou et al. (2011) have shown that also Tunisia can be considered in this regard.

To improve the understanding of the interrelations between climate change, conflict and adaptation, it is in any case necessary to leave the regional perspective and to look into one country in more detail.

4.4 Climate Change Impacts on Agriculture and Adaptation in Morocco

Focusing on Morocco allows us to discuss the impacts of climate change and socio-economic implications with a closer look at the empirical data and policy options.

4.4.1 Traditional Land Use and Recent Developments

The main components of the Moroccan land use sector are farming and pastoral livestock husbandry, which have evolved over centuries under fluctuations in precipitation (Barrow and Hicham 2000). Traditionally, both components are combined which allows to buffer income shocks from droughts (Casciarri 2006).

Farming

To ensure resilience in rain fed agriculture, which is used on more than 90% of the Moroccan arable land (Figure 4.1), special crop mixes and harvesting strategies are traditionally applied. For instance, barley is used instead of wheat because barley needs less water and ripens faster, which increases the capability of resistance against water deficit (Kuhn et al. 2010, Ortiz et al. 2008). Late planting of lentils makes best use of available water after late rains, recognizing shorter temporal fluctuations in rainfall (Lybbert et al. 2009a), whereas fallow accumulates water on a yearly-timescale. An additional buffer is built up by stockpiling grain in good years (Skees et al. 2001).

In the southern part of Morocco, the traditional adaptation of farming to a semi-arid to arid climate is the extended use of surface irrigation systems. Irrigated fields are additionally surrounded by trees such as apple, walnut, almond, olives, and date palms to use the percolating water efficiently (Barrow and Hicham 2000, Rössler et al. 2010).

Since the middle of the 20th century, agricultural patterns have changed substantially. The use of nitrogen fertilizer, mechanization, and the heavy use of irrigation (surface water and groundwater) were promoted with the main objective to increase cereal production (Badraoui et al. 2000, Davis 2006). Especially the more drought prone wheat, Morocco's most important agricultural product over the past decades (FAO 2010b), was supported by many governmental initiatives.

The new mode of agriculture facilitated a maximization of production in years with sufficient rain, while it increased potential severity of droughts. The same is observed for other North African countries (e.g. Latiri et al. 2010). As Figure 4.5 shows, maximum yields and maximum harvested area in Morocco increased over the last 30 years, while the variability of both parameters increased as well.

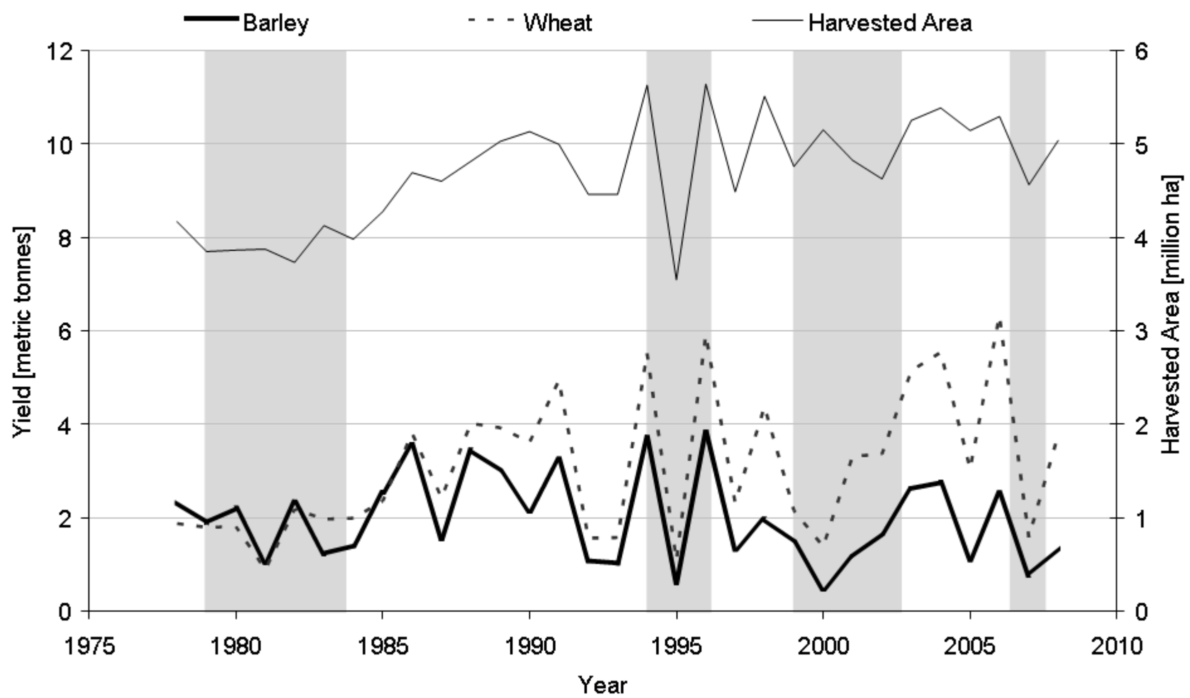

Figure 4.5 Harvested area and yields of barley and wheat in Morocco from 1978 to 2008. Drought periods are indicated with grey background (own representation based on FAO 2010b)

The agricultural model therefore can be characterized as a “higher-risk higher-stakes game” (Lybbert et al. 2009a:6). Despite a higher risk of crop failure, governmental programs advocated the maximization strategy in order to become more independent from cereal imports. For instance, farmers were encouraged to declare property by plowing former collective rangelands (Davis 2006). Additionally, the use of groundwater for irrigation is still free of charge for the southern regions of Ouarzazate and Tafilalet (Badraoui et al. 2000).

Surface-water management projects in Morocco, necessary for expansion of irrigated agriculture in the past, transferred the power over water resources from local to national authorities, which has led to a devaluation of traditional water management. Farmers were therefore encouraged to switch their irrigation systems to groundwater supply, where they control the access to a varying degree themselves (Heidecke et al. 2010). This has led to a massive drop of groundwater tables lowering yields in some areas already (Breuer and Gertel 2007, Kuhn et al. 2010). Additionally, inadequate irrigation techniques have led to an increasing salinization in Morocco. Countrywide 35% of irrigated areas are saline (Badraoui et al. 2000). In the southern province of Ouarzazate 80% of soils are affected by salinization (Davis 2006).

Livestock Husbandry

For livestock husbandry, the most dominant traditional adaptation to fluctuating precipitation is the wandering of herds according to precipitation patterns (transhumance). Animals are slaughtered during times of fodder scarcity even though prices are significantly lower during such periods (Skees et al. 2001). Furthermore, reciprocal grazing arrangements as well as social networks are used to buffer income shocks (Hazell et al. 2001, Kuhn et al. 2010).

From the 1960s on, the government established fodder subsidies as drought relief measures. Since close relations to governmental authorities ensured fodder supply, this enhanced sedentarization, and fragmentation of tribal structures, which formerly controlled access to pastures (Rachik 2007). While the interventions reduced catastrophic losses of livestock in recent droughts (see Figure 4.6), this policy as well as remittances from emigrants made it possible to keep larger herd sizes (Kuhn et al. 2010), thereby contributing to increased grazing pressure. Figure 4.6 shows the number of goats and sheep from 1978 till 2008 which have to be seen in relation to the expansion of cropland by about 25% since 1980 (see Figure 4.5). While precipitation was decreasing, livestock density increased. This contributed to degradation of rangelands in Morocco which is to a significant degree also caused by plowing of marginal lands and an increasing demand in firewood for cooking and heating (Davis 2006, El Moudden 2004, Le Houérou 1996).

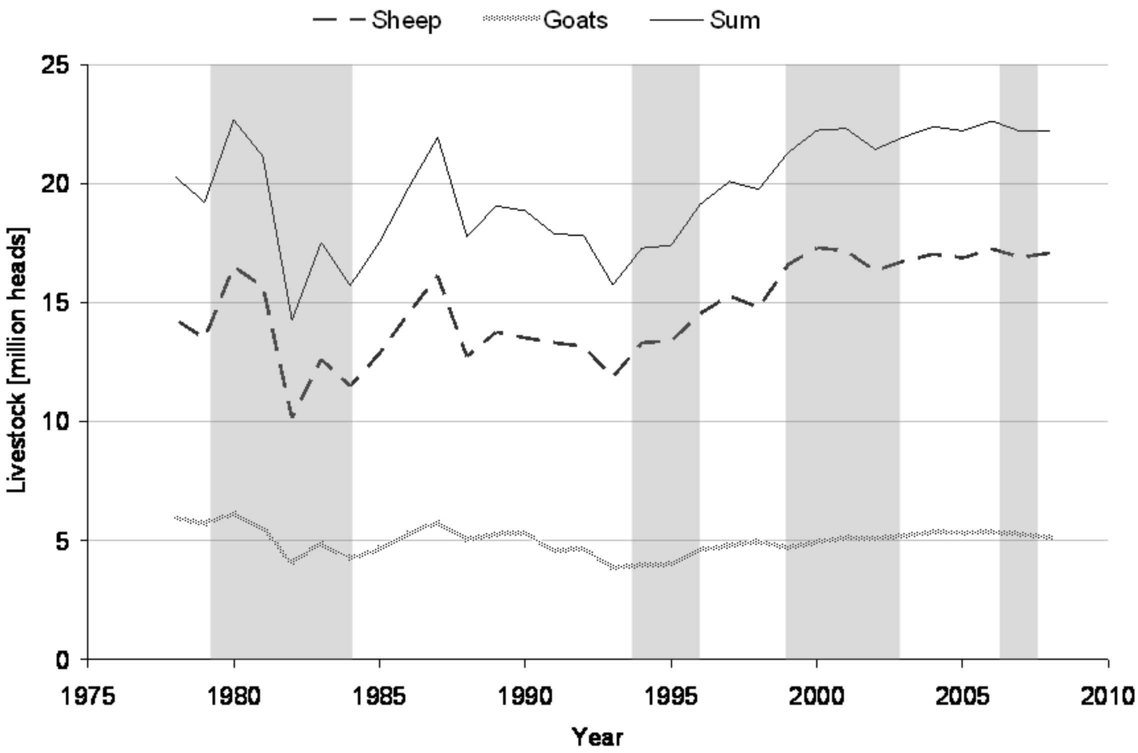

Figure 4.6 Numbers of livestock (sheep and goats) in Morocco in million heads from 1978 to 2008 (own representation based on FAO 2010b). Drought periods are indicated with grey background

Plan Maroc Vert

In 2008 the Moroccan government released a new agricultural strategy, called "Plan Maroc Vert" (PMV; Maroc 2008b). Beside the objective of promoting "aggressively" (Maroc 2008a) the productivity of the agriculture, the PMV addresses as well climate change, overexploitation of groundwater, and alleviation of poverty (Maroc 2011). The strategy is based on two pillars: Pillar one promotes a "modern agriculture, with a high added value and adapted to markets" (Maroc 2008a:1). Pillar two is dedicated to "combating poverty through amelioration of agricultural revenues" (ibid.) of small scale farmers. The PMV is accompanied by planned investments of 12-17 Billion Euro and the proposition to improve cooperation between educational and agricultural institutions (Maroc 2008b).

Measures to increase the agricultural productivity by up to 59% till 2020 are identified as: intensification of production, extension of cropland, improvement of localized irrigation, institutional innovations and an improved processing of products (Maroc 2008a). For instance, the extension of crop areas and improvements in processing are expected to increase the added value of olive products till 2020 by a factor of four (Maroc 2008a). Given the projections of climatic changes in North Africa (see section 3.2), it remains questionable whether the ambitious goals of the PMV can be reached.

4.4.2 Impacts of Climate Change on Agriculture and Implications for Societal Stability

In this section we discuss expected impacts of climate change on agriculture and its implications for income security, social inequality, food security, and hence societal (in-)stability.

Yield Losses

Shifting rainfall patterns and a reduction in average values are projected to decrease the average agricultural productivity in Morocco by around 30% till 2080 (see Table 4.2). Given climate projections for 2030 to 2060, especially legumes and cereals will be affected by less favorable growing conditions, thereby decreasing productivity by 15% to 40% (Giannakopoulos et al. 2009). Prospects of further yield increases for cereals are generally limited (Latiri et al. 2010).

Higher rates of evapotranspiration can increase salinization of irrigated farmlands, depending on human management. It has been shown for Morocco that within less than 20 years, irrigated soils can suffer a loss of more than 50% of their productivity through salinization (Badraoui et al. 1998). Hence, salinization is critical as it can considerably aggravate negative impacts of climate change. These impacts will hit hardest the poorer parts of the Moroccan population who mainly rely on agriculture for income (Maroc 2011; Thomas, 2008).

Soil erosion in general threatens the possibility of North African countries to adapt to climatic changes (e.g. Iglesias et al. 2010). Already 75% of arable lands in Morocco are affected by erosion (Maroc 2011). Future land use is decisive for erosion rates. In this regard the government’s aim to increase the share of olives and citric fruits is promising, since perennials can reduce erosion if understory is allowed (Maroc 2008b).

Droughts

As shown in section 2, the drought risk for Morocco is increasing in the future. It is therefore of interest to investigate impacts of past droughts. Each drought in the past decades invariably included one year of drastic yield reduction. The most recent drought of 2007 in North Africa hit Morocco hardest, causing the wheat production to drop by 76% (compared to 2006). To compensate for the losses, the government significantly increased the import of cereals over the past decades (FAO 2010b). Consequently, the wheat supply per capita was not as strongly affected as the production. In general, undernourishment has not been a widespread problem in Morocco (FAO 2010b, see also section 3).

However, there are some indications for a link between drought, food security and social instability in Morocco. In 1981 and 1984, drought “played a pivotal role” in “food-related insurrection” and “greatly exacerbated existent social and economic problems” (see also Brauch 2012, Swearingen 1992:408ff). More recently, riots broke out in Morocco in early 2008 after a year of severe losses in food production (see Fig 5 and Guardian 2008). However, the drought related production losses were only one factor leading to social disruptions. High global food prices as well as national policies also played a significant role in the outbreak of violence (Swearingen 1992). Further, the violence did not destabilize Morocco nationwide but rather occurred on a localized level. Regarding an increasing urbanization and strong population growth, it is therefore essential to avoid price shocks and food insecurity.

Social Inequality

Contribution to social inequality can be another effect of more frequent and intense droughts. In rural areas of semi-arid Morocco, pastoralism offers jobs for up to 38% of the working population (Maroc 2008a). Wealthier families rely less on natural resources, because they can afford buying fodder during droughts (Hazell et al. 2001, Kuhn et al. 2010). Consequently, total animal numbers are increased artificially during times of fodder scarcity (see Figure 4.6). For the poorer livestock owners, the impacts of droughts thereby become more severe, because the high grazing pressure leaves little reserves for buffering fodder scarcity without subsidized or purchased fodder. After droughts, the herds of poorer farmers will then be more reduced in size than the herds of wealthier ones. They are then in a position to use a recovering vegetation more efficiently (Zimmerman and Carter 2003). Therefore, poorer families might get poorer and wealthier ones more wealthy if no social adjustment mechanisms are in place (Lybbert et al. 2009a).

4.4.3 Future Options of Adaptation

As shown, shifting precipitation patterns have the potential to contribute to societal inequality and instability. It is therefore important to consider pre-emptive agricultural and socio-economic policies which seriously take into account climate change and its societal implications. Figure 4.7 summarizes possible adaptation strategies of private actors and shows the potential influence of governmental institutions.

Farmers and pastoralists can either adapt to climate change or switch to alternative livelihoods (Figure 4.7). However, alternative livelihoods indirectly affect agriculture. For example, nomads who decide to settle increase demand in firewood in the surroundings of settlements. This in turn decreases fodder availability for sedentary livestock. Hence, each policy needs to be sensitive to the described complexity of the actor-actor and human-environment interlinkages.

Farming

Since options for expanding irrigated areas are limited, adaptation in agriculture has to arise from altered land use practices. As shown, average yearly precipitation is decreasing in Morocco, but monthly precipitation is likely to increase from December to February. Thus, the supply of water by precipitation and soil storage can be sufficient for cereal farming if the negative effects are addressed by shifts in planting patterns (Latiri et al. 2010).

As shown, shocks from droughts are amplified by intensified agriculture and the expansion of cropland (Figure 4.5). The focus of agricultural production should therefore be shifted from *maximization* towards *stabilization* of outputs. This would have two effects: First, the year to year variation in agricultural outputs would decrease, which in turn increases efficiency due to a more continuously usage of processing capacities.

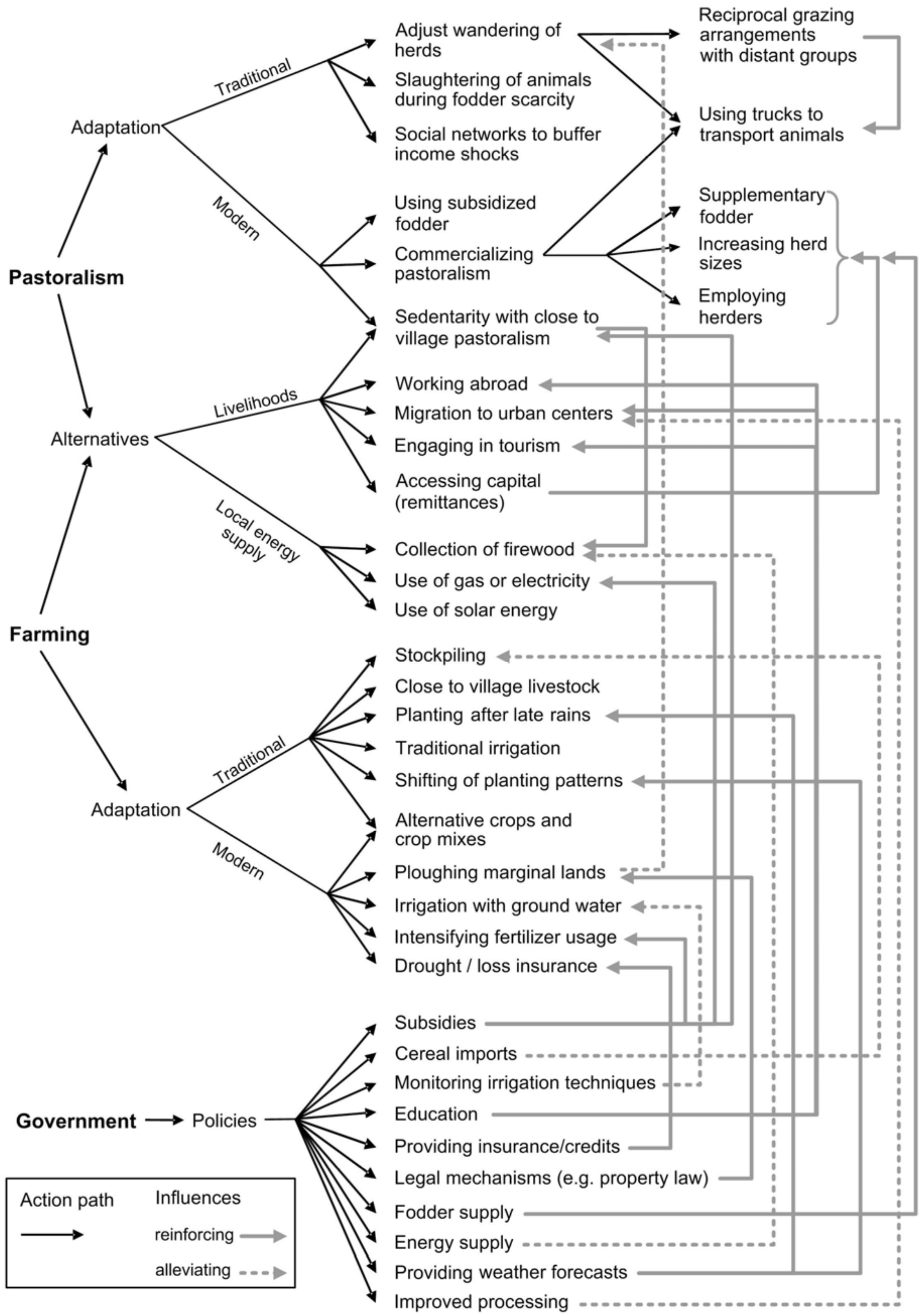

Figure 4.7 Adaptation options and action paths of pastoralists, farmers and the government in Morocco (own representation)

Second, even though prices of agricultural goods would be higher in good years due to lower domestic supply, which stimulates other adaptation mechanisms, production losses in years of drought would be reduced by producing on more fertile soils, and by using groundwater primarily to buffer years of drought. In this way, price shocks during droughts would be reduced. Because food riots are significantly influenced by international food prices, a reduced dependency from international food markets in years with limited rain will therefore reduce conflict potential caused by climate change.

Within a shift to stabilization, much more emphasis should be given to salinization of soils: A higher present-day output under irrigation will come at a high price of severe losses in the future if inadequate techniques are used (Badraoui et al. 1998). Therefore, every irrigation project should be accompanied by measures to ensure seepage, and a monitoring of the hydrological system (see Figure 4.7).

At the producers' side of agricultural products, area-based rainfall insurances can buffer income shocks during droughts. Rainfall insurances can improve the resilience against droughts without interfering significantly with the actual land use strategies (Hazell et al. 2001, Skees et al. 2001). However, a rainfall insurance program of the World Bank failed in Morocco in the 1990s because of a continuing non stationary downward trend in precipitation (Lybbert et al. 2009b), indicating certain challenges for implementation.

As shown, there is a certain potential in seasonal weather forecasting for Morocco. Substantial losses of investments due to crop failure in rain fed areas could therefore be decreased. Even yield increases could be achieved by using seasonal weather forecasts because farmers often hesitate to apply adequate amounts of fertilizers in order to minimize losses of investments (Latiri et al. 2010).

Pastoralism

Given the dependence on socio-economic boundary conditions, the development of the pastoral livestock sector in Morocco is hardly predictable. If precipitation will become too scarce in order to pursue pastoralism, 38% to 50% of transhumant pastoralists in the south indicate to give up transhumance and opt for sedentarity as the main alternative (Freier et al. 2012). However, sedentarity with irrigated agriculture will put further pressure on groundwater resources and arable lands (Kirscht 2008). In order to activate other livelihood alternatives, such as working abroad or engaging in tourism, it can be shown that a better access to capital as well as education are prerequisites (Freier et al. 2012; see also Figure 4.7).

Many governmental options which have been used in the pastoral sector with respect to drought mitigation risk "achieving little more than postponing disaster and […] interfering with indigenous recovery systems" (Blench and Marriage 1999:20). In contrast, traditional property rights have managed rangeland ecosystems mostly in a sustainable way by incorporating local ecological knowledge. This has been rarely appreciated by governmental institutions (Davis 2006, Linstädter et al. 2010). Re-arranging traditional management systems within governmental and communal institutions whilst preserving their traditional core will therefore contribute to a higher resilience of pastoral livelihoods.

A more recent option for adapting the pastoral sector is commercial pastoralism. It is characterized by increased herd sizes, trading of animals for supplementary fodder, employing additional herders, and using trucks to move herds to adequate pastures ("truck transhumance"; Breuer 2007 and Fig. 7). Commercial pastoralism allows livestock owners to decrease dependence from price fluctuations and weather variability. For many pastoralists, commercial pastoralism is seen as an attractive alternative but having sufficient capital is a prerequisite (Freier et al. 2012), which indicates again a problem of social inequality.

Commercial pastoralism additionally can cause social conflicts over the access to and property rights of pastures (Breuer 2007). Further, commercial pastoralism promotes degradation of rangelands if destocking during droughts is insufficient and high stocking rates of local and non local herds coincide. It is therefore important that innovations emerging from the private sector which have the potential to abate impacts from climate change, are examined for possible negative side effects. Regulation of these side effects can then be addressed by communal or governmental institutions.

Rural Energy Supply

The plan of the Moroccan government to install solar power plants (Maroc 2010) offers an interesting option for adaptation to climate change, because it combines a stimulus for economic development in rural areas with the possibility of replacing firewood demand by solar powered electricity.

In Morocco, the majority of energy demand in rural areas is currently satisfied through firewood (El Moudden 2004) placing significant pressure on vegetation. Using a bio-economic model of pastoral livestock husbandry, we have investigated the potential of replacing firewood collection from rangelands in order to increase buffering capacities of the vegetation. The model was parameterized for the village Taoujgalt located in the Ouarzazate province south of the High Atlas Mountains (see Figure 4.1 for exact location). The pastures of the village's sedentary livestock are situated at an altitude of 1900 meters with an average precipitation of 270 mm per year. A detailed description of the model can be found in Freier et al. (2011). We simulated reductions in precipitation as projected for the 21st century, and left it to the model to arrange grazing intensities. The model used the objective of optimizing revenues with planning horizons of two and five years, and with perfect foresight (indicated as "optimal" in Figure 4.8). Additionally, we investigated a scenario, where we assumed an alternative energy supply and disabled collection of firewood from rangelands.

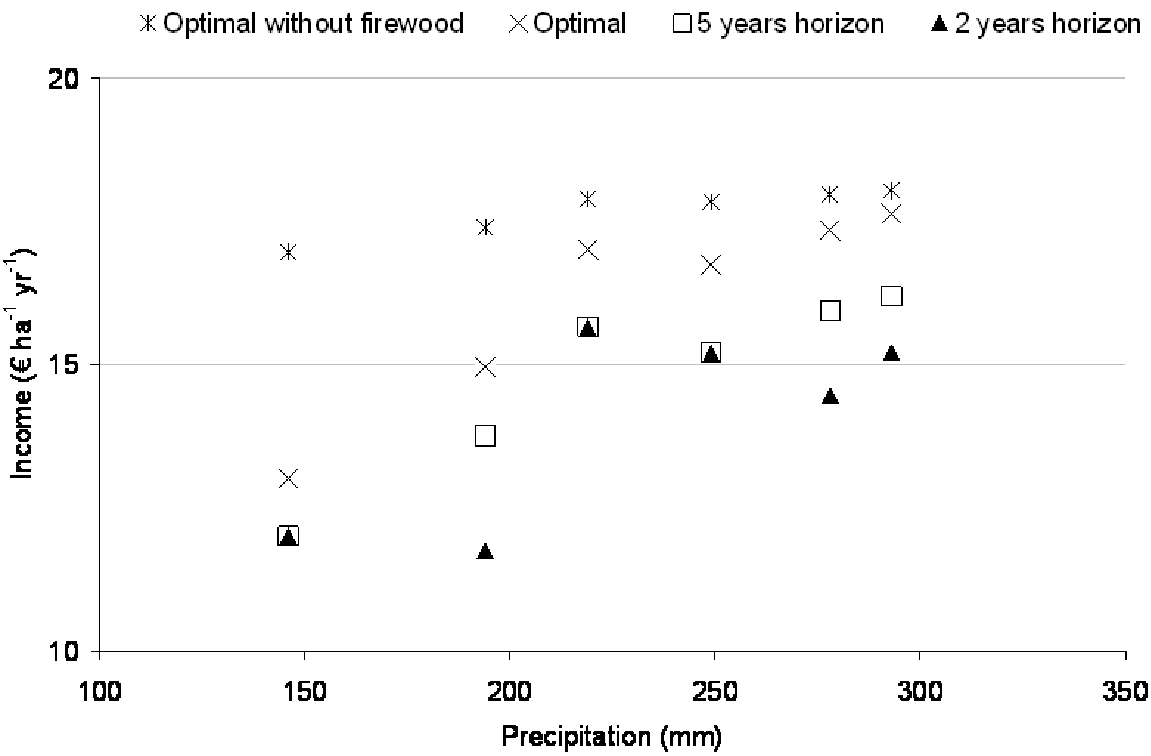

Figure 4.8 Income from livestock husbandry without transhumance (own calculations). Different optimization horizons were used. Optimal: land users have perfect foresight and maximize their profits over 20 years; Five and two years horizons: land users optimize only with respect to the given time horizon (myopic behavior); Without firewood: energy demand for cooking and heating is covered by other sources than firewood from rangelands

The results of the simulations (Figure 4.8) show the potential of compensating impacts of climate change on rangelands by replacing firewood as traditional energy source. Even under a scenario with a reduction of precipitation by 45% (less than 150 mm in Figure 4.8), revenues from pastoral livestock husbandry without firewood collection are still higher than present-day values with firewood collection.
Replacing rural energy supply is therefore legitimately considered as a promising remedy to increase resilience against droughts and agricultural productivity of semi-arid rangelands (Le Houérou 1996). Hence, the solar power initiative of the Moroccan government can contribute to climate change adaptation through positive economic and environmental effects.

4.5 Summary

The trend of increasing annual mean temperatures and decreasing precipitation which has been observed for the second half of the 20th century in North Africa is likely to continue and to cause warmer and drier conditions. Temperatures are likely to rise between 2 and 3°C while precipitation is likely to decrease between 10% and 20% until the year 2050 under the SRES A1B scenario. Northwestern Africa could experience a very strong warming of up to 6°C in the 21st century. Although projections of future climate change exhibit considerable uncertainties, both the frequency and the duration of droughts are likely to increase in northern Africa.
Water scarcity (highest in Libya and Algeria) and the dependency on rain fed agriculture (highest in Morocco) contribute to the sensitivity of the region. The sensitivity is increased by population growth which is strongest in Egypt. The adaptive capacities of the North African states are lower than in Europe but higher compared to the average of the African continent. Low per capita income and its unequal distribution (most unequal in Morocco and Tunisia) limit the generic adaptive capacity while the high level of corruption is a general weakness of the impact specific adaptive capacity. In summary, climate change exposure, pronounced sensitivity and limited adaptation capacities make the region and Morocco in particular vulnerable to climate change. Concerns that the vulnerability to climate change could contribute to social instability are reasonable. Despite the political and social changes of 2011, our analysis of conflict implications find Algeria, Egypt and Morocco to be most prone to climate change related instability.

In Morocco, the social stability has already been affected by past droughts. Climate change is likely to cause a decrease in primary agricultural production in the 21st century in Morocco of 15% to 40%. Future droughts additionally have the potential to increase social inequality, and threaten social stability through severe shocks in food prices. Both, reduction in productivity and impacts of drought will be strongly aggravated by soil degradation, mainly due to salinization if the current development is projected into the future.

The incentives used in the past to increase the agricultural production in Morocco are inadequate to buffer effects of droughts, especially for the poorer part of the population which still depends largely on income from agriculture. On the contrary, some recent developments like cropping of marginal lands, depletion of groundwater resources, and the growing of wheat instead of the traditionally used barley are likely to increase the vulnerability of the agricultural sector to climate change.

The new agricultural strategy of Morocco "Plan Maroc Vert" addresses some of these issues as it builds on two pillars: output maximization for industrial agriculture and the fight against poverty for small-scale agriculture. The emphasis on increasing the added value of agricultural products such as from olives indicates a shift in policy, which has additionally the potential to create job opportunities in rural areas. However, agriculture is still seen as a major motor of the future Moroccan economy which bears the risk of increasing present-day output while sacrificing future durability.

We find a great variety of policy options for adaptation. In general, it can be recommended to switch the focus of agricultural production from maximization to output stabilization. For rain fed agriculture, the shifting of planting patterns and crop types is able to reduce impacts of climate change substantially, but a monitoring of irrigation practices and soil conditions will be crucial to secure future productivity. Area based rainfall insurances as well as a future improvement of seasonal weather predictions are further options to reduce vulnerability.

Since poorer parts of the population have less options of adaptation and will be affected more heavily, agricultural interventions should be accompanied by measures which balance social inequalities and contribute to social stability.

A commercialization of pastoral livestock husbandry can be recommended if it is closely linked to an empowering of traditional management institutions. Additionally, our bio-economic model shows that a replacement of firewood by electric energy supply is able to over-compensate the impacts of climate change on semi-arid rangelands. Pushing forward the development of solar power plants in arid areas, as envisioned by the Moroccan government, is therefore promising because it combines a stimulus for the domestic economy with the adaptation to climate change.

4.6 Conclusions

The significant challenges posed by climate change increase the importance of adaptation in North Africa. Adaptation measures have to address the specific elements of exposure and sensitivity to efficiently reduce vulnerability. Further, adaptation to climate change cannot be achieved by one sector alone.

For the agricultural sector, strategies are most promising which focus on conservation of productive assets instead of depleting them to maximize present day output. A mismanagement of soil quality, rangeland vegetation, and groundwater extraction will have severe consequences in the future since it amplifies the impacts of climate change.

There are many options for adaptation to climate change available in agriculture. In the past, traditional options have been considerably altered and partly devaluated in the course of a restructuring of institutional regulation. In order to take advantage of the full spectrum of technological innovations such as localized irrigation and commercial pastoralism, it is necessary to have strong monitoring mechanisms to ensure a sustainable application. The efficiency of the monitoring mechanisms depends on the degree to which they include local and specific knowledge. This suggests a decentralization of structures and strengthening of private and institutional cooperation.

Failure to implement policies which address both, agriculture specific needs and socio-economic developments, considerably increases the risk that climate change contributes to social inequality and instability in North Africa.

5. Climate Change and Land Use Conflicts in Northern Africa[37]

Abstract

For centuries, Arab nomads and African villagers alternately skirmished and supported each other as they raised livestock and tended fields under resource-constrained conditions. The delicate balance has been upset by drought, desertification, crop failure and wide-spread food insecurity. While the interactions are not sufficiently understood, there are growing indications that warming in Africa could become a significant factor of violent conflicts in the coming decades. To test such projections this paper first gives an overview of North Africa's conflict vulnerability and expected climatic changes. Secondly, the paper discusses past and ongoing farmer-herder conflicts in different regions of Mali. Finally, a model framework is built for analyzing the farmer-herder conflict in northern Africa, taking into account key environmental and economic variables and feedbacks.

5.1 Introduction

Violent conflicts over land are not a recent phenomenon in northern Africa. For centuries, the relationship between herders and farmers has been shaped by both *cooperation and violence* (Blench 2004, Breusers et al. 1998, Gallais 1975, Moritz 2006, Scoones 1995, Shettima and Tar 2008). However, strong population growth, wide-spread food insecurity and a recent series of drought events has increasingly challenged traditional resource sharing mechanisms while fights for scarce land resources have intensified (Bächler 1998, Herrero 2006, Hulme et al. 2001, Hussein 1998, ILRI 2006, Turner 2004).[38] Meanwhile there are growing indications that warming in Africa could become a significant factor of violent conflicts in the coming

[37] This chapter has been published as Schilling, Janpeter, Scheffran, Jürgen, Link, P. Michael 2010. Climate Change and Land Use Conflicts in Northern Africa. In: Endlicher, W., Gerstengarbe, F.-W. (Eds.), Continents under Climate Change. Nova Acta Leopoldina, Halle, pp. 173 –182. As the lead author, Janpeter Schilling is responsible for more than 90% of the chapter's content.

[38] For a general discussion of the security implications of climate change in Africa see Brown and Crawford (2009). An introduction to the climate-security subject is given in Scheffran (2009). See also Brauch et al. (2003) , UN General Assembly (2009), WBGU (2008), Barnett and Adger (2007), Nordås and Gleditsch (2007).

decades (Barnett and Adger 2007, Burke et al. 2009). This raises the question, in which way climate change affects the sharing of land resources between farmers and herders. Will it lead to more conflict or will it promote cooperative solutions? The paper explores these questions in three steps. First, it gives an overview of the general *conflict vulnerability* and *expected climatic changes* in northern Africa.[39] Next, one particular country is selected for a discussion of farmer-herder conflicts. Finally, conclusions are drawn from the previous steps to build a *model framework* for analyzing farmer-herder conflicts in northern Africa in general.

5.2 Conflict Vulnerability and Climatic Change in Northern Africa

In this research context, northern Africa refers to the eleven African states whose state territory is mainly or entirely located above 15° N (see Table 5.1).[40] This broader definition allows for a more comprehensive view on the conflict vulnerability and climate change impacts on the region.[41] To estimate the basic conflict vulnerability of the region, this section takes a brief look at some indicators that have been identified by previous studies (Collier 2000, 2008, Collier et al. 2003, Homer-Dixon 1991, 1994, 1999) to potentially contribute to violent conflict.[42] According to Homer-Dixon's environmental scarcity theory (1994, 1999) environmental change likely leads to violent conflict when it is combined with *population growth* and *unequal resource distribution*. Northern Africa is an economically, politically and socially heterogeneous region.

However, the states share a common development: *strong population growth*. The total population of the region is expected to grow from currently 247 million to 322 million in 2025 and 430 million in 2050 (see Table 5.1).

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[39]This should not be misinterpreted as a simplification of the climate-conflict complex but rather be seen as a first basic identification of possible conflict vulnerable regions which are already facing significant climatic changes.

[40]Thereby the definition extends the UN definition of Northern Africa by three states (Mauritania, Mali, Niger), usually attributed to Western Africa, and Chad, usually attributed to the Central or Middle Africa (UN 2000).

[41]Based on the UN's definition of vulnerability, we define conflict vulnerability as the measurement of the extent to which a community, structure, service or geographical area is likely to be damaged or disrupted by the impact of violent conflict (UN 1997:76).

[42]We define violent conflict as a conflict between two or more parties in which at least one party uses violence to achieve its goal. For a typology of violent conflicts over natural resources see Hussein et al. (1999:401).

Table 5.1 Population, economy, human development and conflicts in northern Africa (PRB 2009, PRIO 2009a, b, UNDP 2009)

State	Population (in millions) 2009	2025	2050	Gini index*	GDP per capita** (PPP US$)	HD*** in 2007	Number of conflicts 1989-2008	Dominant conflict intensity
Sudan	42.3	56.7	75.9	N/A	2086	medium	20	war
Algeria	35.4	43.7	50.5	35.3	7740	medium	18	minor armed conflicts and war
Chad	10.3	13.9	20.5	39.8	1477	low	16	minor armed conflicts
Niger	15.3	27.4	58.2	43.9	627	low	8	minor armed conflicts
Egypt	78.6	99.1	122.3	32.1	5329	medium	6	minor armed conflicts
Mali	13.0	18.6	28.3	39.0	1083	low	4	minor armed conflicts
Morocco	31.5	36.6	42.4	40.9	4108	medium	1	minor armed conflicts
Western Sahara	0.5	0.8	0.9	N/A	N/A	N/A	1	minor armed conflicts
Libya	6.3	8.1	9.8	N/A	14364	high	0	
Mauritania	3.3	4.6	6.9	39.0	1927	medium	0	
Tunisia	10.4	12.2	13.9	40.8	7520	medium	0	
Total:	246.9	321.7	429.6				74	

*average 1991-2007, the Gini index lies between 0 and 100. A value of 0 represents absolute equality and 100 absolute inequality; **in 2007; ***Human Development

Mali and Chad are expected to double and Niger even to almost triple their population by 2050. Sudan is projected to see an increase of 34 million people between now and 2050. For the region as a whole and especially for the states mentioned, it can be stated that the population pressure will increase considerably over the next 40 years. Since no state-based index exists that measures the distribution of land resources, the Gini index is used to assess the wealth distribution within the countries. Most considered states show a *medium level of economic inequality* of around 40 (Table 5.1). Positive exceptions are Egypt and Algeria, while Niger has the highest level of economic inequality.

Unlike Homer-Dixon (1991, 1994, 1999), Collier (2008) does not consider inequality to be a major driver for civil war. He rather stresses the importance of *poverty* as a pre-condition for violent conflict (ibid.). Additionally, he and his associates conclude that states who have experienced violent conflicts before face a significantly higher risk of violence, especially within the *5 year post-conflict phase* (Collier 2008). Table 5.1 shows that 8 out of the 11 states considered have experienced armed conflicts in the period between 1989 and 2008.[43] Following PRIO's definition, the vast majority of

[43]PRIO uses the UCDP definition of armed conflict: "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths" (PRIO 2009a:1).

these armed conflicts were internal and of minor conflict intensity.[44] Only in Algeria and Sudan conflicts were temporarily or mainly classified as war.[45] Most armed conflicts of minor intensity took place in Chad followed by Niger, Egypt and Mali.

The economic situation expressed in per capita income shows a clear north-south distinction. While the northern states are economically stronger, the poorest countries, namely Niger, Mali and Chad, are all located in the south of the considered region. The degree of human development mainly mirrors the economic situation, with Libya being the only highly developed nation. Niger is last on the human development ranking which includes 182 states, closely followed by Mali (rank 178) (UNDP 2009). After this first evaluation of regional conflict vulnerability, three states seem to be adequate for a more detailed discussion. Mali, Niger and Chad meet the population growth criterion by Homer-Dixon (1991, 1994, 1999) as well as the poverty and previously-violent conflict criteria by Collier (2008). The following paragraph will briefly describe the current climatic situation in northern Africa and discuss the expected changes.

Large parts of northern Africa are covered by the Sahara desert and shaped by a semiarid to hyper-arid climate (DePauw 2000, Tucker and Nicholson 1999). The region has an overall low level of soil moisture with strong seasonal variations (see Japan Aerospace Exploration Agency 2004). Between 1901 and 2005, the annual precipitation has declined in all states, in the majority by more than 40 % (Bates et al. 2008).[46] The surface temperature in northern Africa has increased by 1 to 2 °C between 1970 and 2004 (IPCC 2007b). Projections of precipitation and temperature change for northern Africa currently lack precision due to insufficient climate data and limited computational and human resources (Boko et al. 2007, Ceccato et al. 2007, Giannini et al. 2008, Stuut et al. 2008). However, most studies suggest a continuation of the current trend of *increasing temperature and decreasing precipitation* (Bigio 2009, Burke et al. 2009, Hulme et al. 2001, Paeth and Thamm 2007, Stige et al. 2006). The IPCC estimates a temperature increase for northern Africa of 2 to 3 °C by 2100 compared to 1900 (Christensen et al. 2007). Based on data from the Hadley Centre, the German Advisory Council on Global Change expects a significant

[44]"Internal armed conflict occurs between the government of a state and one or more internal opposition group(s) without intervention from other states" (PRIO 2009a:7). A conflict of minor intensity has between 25 and 999 battle-related deaths in a given year (ibid.).

[45]To be classified as "war", the number of battle-related deaths in a given year has to reach at least 1000 (PRIO 2009a:7).

[46]It is noted that for most parts of the Sahara desert data are not sufficient to produce reliable trends (ibid.).

increase of drought risk, especially for the western part of the considered region (WBGU 2008). UNEP estimates that the boundary between semi-desert and desert has shifted southward by 50 to 200 km since 1930 and it is expected to continue to do so as precipitation declines (UNEP 2007).[47] Between 90 million and more than 140 million people in North Africa could suffer from *water stress* in 2055 if the global temperature exceeds 1.8 °C compared to preindustrial levels (Boko et al. 2007).

Even without climate change several countries in North Africa will exceed the limits of their economically usable land-based water resources by 2025 (Bates et al. 2008). While the food consumption in the northern countries of the considered region is currently high and only expected to deteriorate slightly in the future (by about 4.4 % between 2008 and 2018 on average), the states of the Sahel already face *wide-spread food insecurity* which is expected to worsen (FAO 2009, Herrero 2006, Shapouri et al. 2009). Cline (2007) roughly estimates the agricultural productivity of Morocco, Algeria, Mali and Sudan to drop by more than 25 % until 2080 (compared to 2003 levels), even if effects of carbon fertilization are incorporated. Niger is estimated to see a decline of agricultural productivity between 15 and 25 % while Egypt could increase its agricultural productivity over the same time period by more than 25 % (Cline 2007).[48] A recent study by the International Food Policy Research Institute calculates that due to climate change the rice production in the Middle East and North Africa could be 30 to 40 % lower in 2050 compared to a situation without climate change, while the production of other crops (wheat, maize and millet) would experience a reduction of less than 10 % or even a slight increase of less than 1 % in the case of sorghum (Nelson et al. 2009).[49] In summary, the majority of studies indicate that *climate change will aggravate water stress and scarcity*. That "could generate conflicts over water, particularly in arid and semiarid regions" (Bates et al. 2008:79). Against this background, Mali appears to be particularly appropriate for a climate change related discussion of farmer-herder conflicts.

5.3 Farmer-Herder Conflicts in Mali

Mali's population combines diverse lifestyles and ethnicities. The dominant group is the Manding including the Bambara and Malinke who are farmers and together

[47]For a critical discussion of this estimate see Benjaminsen (2008).
[48]No estimates were provided for the remaining countries considered here.
[49]The study did not consider the use of carbon fertilizers.

account for about half of the total population. Other groups of mostly settled farmers are the Senoufo (9.7 % of the total population), the Songhai (7 %) and the Soninké (7 %). The nomadic Tuareg and Maur herders (together 5 %) are a minority while the Fulani, a hybrid group of cattle herders and sedentary farmers, are the second largest ethnic group (Minority Rights Group International 2007). For centuries the different groups have lived side-by-side in *both supportive and conflictive relationships*.[50] However, over the past decades indications of *intensifying land use conflicts* in Mali have accumulated (Ba 1996, 2008, Beeler 2006, Benjaminsen 2008, Benjaminsen and Ba 2009, Moorhead 1991, Pedersen and Benjaminsen 2008, Turner 2004). Beeler (2006) reports how Fulani herders increasingly have difficulties to find pasture and access to waterholes in northwest Mali. The local Soninké farmers accuse the herders of letting their livestock consume the millet stalks after the harvest, occasionally leading to the killing of stray animals by the Soninké.[51] This conflict is superposed by conflicts over land and water within groups of farmers and herders (Beeler 2006). Another region of conflict is the inland Niger delta of Mali located in the Sahel (100 to 600 mm of annual rainfall) which stretches roughly south from Timbuktu to Segou along the Niger river (compare Economist Intelligence Unit 2010, FAO 1997). While paddy rice is planted in shallow water, burgu grows in deeper water (de Vries et al. 2010, Dingkuhn 1995). Since 1950 the maximum flood levels of the Niger river have decreased overall and especially during the droughts of the 1970s and 1980s (Direction Nationale de l'Hydraulique et de l'Energie, Bamako in Benjaminsen and Ba 2009). This has led the Songhai farmers to move their rice field continuously into the burgu growing areas (Moorhead 1989). Over the past 50 years about one quarter of the burgu areas in the delta has been converted to rice fields (Kouyaté in Benjaminsen and Ba 2009). Since the Tuareg depend on the burgu to feed their productive livestock during the dry grazing season from December to June, a land use conflict has evolved which occasionally leads to violence between the Touareg and the Songhai (Benjaminsen 2008).

At the same time the delta has seen a strong population growth of about half a million people between the mid 1960s and the late 1990s (Cotula and Cissé 2006).[52] While

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[50]Tonah speaks of "symbiotic economic relationships" (2006:157) between farmer and herders in Ghana, while Moritz even sees agriculture and pastoralism in West Africa as "one integrated production system" (2006:8).

[51]An overview of the growing and harvesting season as well as of the herder movement can be found in USAID (2009:1).

[52]Also see table 1.

recognizing this development, Benjaminsen and Ba (2009) warn against seeing the combination of droughts and the growing population as the main cause for conflict. The authors rather identify a policy driven marginalization and discrimination of herders as well as a general state agenda of agricultural modernization as root causes. However, they state that "the droughts of the 1970s and 1980s played a role in the agricultural encroachment that was driving the conflict" (Benjaminsen and Ba 2009:79). After analyzing the impact of the same droughts on the Tuareg rebellion in northern Mali between 1990 and 1996, Benjaminsen (2008) draws a similar conclusion. The rebellion was mainly based on dissatisfaction with state policies which economically and socially strongly disadvantaged the herders. Only the migration movements of young men to Algeria and Libya "where they were exposed to revolutionary discourses" (Benjaminsen 2008:832) were attributed to the droughts. Bächler (1998) as well as Kahl (2006) place a stronger emphasis on the relationship between land scarcity and the outbreak of the Tuareg rebellion. "Land and water stress is severe in Mali" (2006:233) states Kahl and stresses that the fear of the Tuareg was mainly fuelled by "the biased manner in which the government handled famine relief during the periods of droughts" (Kahl 2006:235).[53]

As we have seen, *farmer-herder conflicts are highly complex* since they are affected by a variety of ethnic, socio-economic and political factors. Climate change already acts as an *additional factor* and will likely continue to do so. How exactly and to what extent is not yet fully understood. To overcome this knowledge gap and to better understand the diverse feedbacks caused by climate change new approaches need to be developed. Moritz (2006:28) urges "to consider more explicitly that individuals are strategic actors who may have to gain from the conflicts". Benjaminsen and Ba (2009:79) also call for "a combination of structural and actor-oriented approaches". The following model framework represents such an approach.

5.4 Model Framework for Analyzing Farmer-herder Conflicts in Northern Africa

The previous sections have shown that causal relationships within and between the human and the climate system are complex. To improve the understanding of these

[53]The preferential treatment of farmers over herders by the state government was also identified by Clanet and Ogilvie (2009) as a central cause for conflict between the two groups in the Volta Basin.

relationships it is important to describe them *schematically and actor-centered*.[54] The *impact graph* in Figure 5.1 visualizes some of the most important relationships between system variables and key actors.

In the course of climate change precipitation is likely to decrease in northern Africa while land degradation is expected to increase (see previous section). This development negatively affects the two central resources needed by both farmers and herders: water and land. While only a small portion of water is consumed or used by farmers and herders directly for their own wellbeing, the major amount of water is consumed by plants or animals respectively. The two groups of actors may manage to cope with a certain reduction of available land and water and therefore a reduced yield or livestock production. However, if the loss of production reaches a critical threshold which threatens the minimum calorie intake of one or both groups, the *actors are forced to act*. Then, several options are possible. Theoretically, farmers could switch to a crop and herders to a livestock that needs less water while guaranteeing a similar production level. Since the plants and animals can already be considered to be well adapted to the given resource basis and a shift would require significant investments, this option does not seem to be likely. Another option could be to more efficiently use the resources through an increase of labor or through closer cooperation.[55] The already existing exchange of goods such as milk for rice could be intensified or the lifestyles could partly converge.[56] To preserve their original lifestyles, both groups could move to more fertile areas. Especially, herders could use this option as they have a higher level of mobility. However, with an *overall reduction of fertile land* this can become increasingly difficult. The example of Mali shows how a direct movement of farmers into grazing areas and of herders into farming land can lead to conflict. This is especially likely when the movement by one actor is perceived as an aggressive act by the other and when this perception is combined with additional factors such as political and social marginalization (Tuareg in Mali), migration and population growth (see Figure 5.1 and Table 5.1).

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[54]For an introduction on theories and models of the climate-security link see Scheffran et al. (2011, 2012b).

[55]For example a better use of the livestock's excrement as manure for the fields.

[56]Cissé sees the “transformation of nomadic herders into cultivators and the tendency for cultivators to become herder-farmers” (1981:321) as a result of the droughts in the 1970s and 1980s.

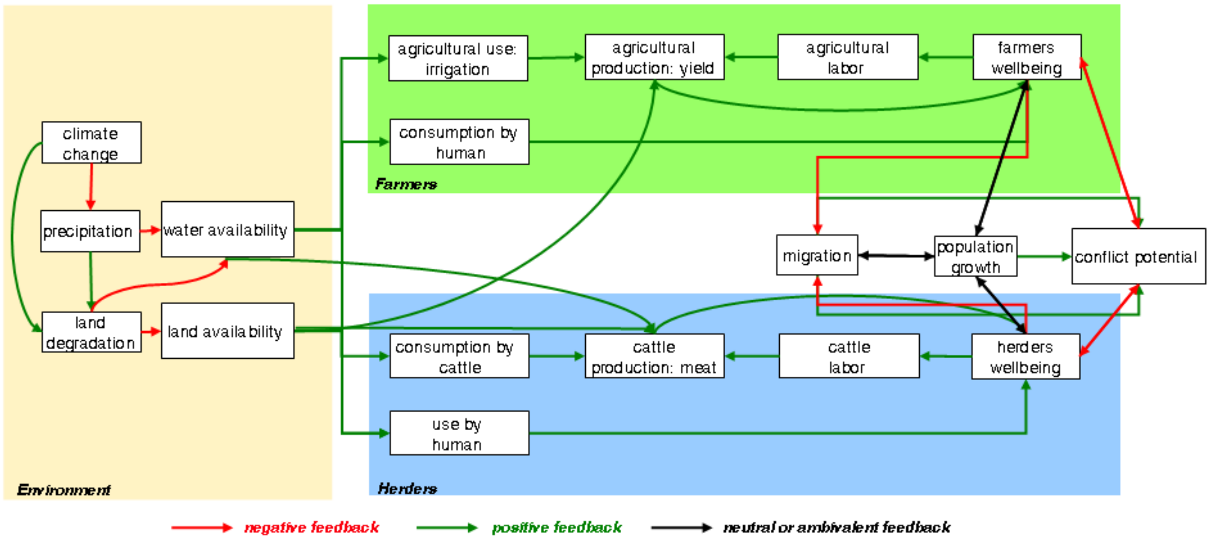

Figure 5.1 Schematic overview of the water and land use conflict in northern Africa (own representation)

5.5 Conclusion

Conflicts between herders and farmers over resources are neither a recent phenomenon nor directly caused by climate change. However, climate change will likely *aggravate resource scarcity* in northern Africa. As seen in Mali, climate change does play a role in conflicts. The extent to which climate change is relevant for conflicts is currently discussed controversially and not yet fully understood. To contribute to the understanding of the linkages between climate change and farmer-herder conflicts, a model framework has been presented. This framework serves as a basis for social network analysis and agent-based modeling, which, combined with qualitative case-studies, further deepens the understanding of the processes driving land use conflicts in northern Africa.

PART III KENYA

6. On Raids and Relations: Climate Change, Pastoral Conflict and Adaptation in Northwestern Kenya[57]

Abstract

Turkana in northern Kenya is highly vulnerable to climatic changes. More frequent and prolonged droughts in combination with socio-economic developments and the availability of small arms have increasingly overwhelmed existing adaptive capacities. Under these conditions conflicts, closely related to violent livestock theft, among pastoral groups tend to increase. This chapter analyses possible linkages between climate change and livestock raiding in Turkana, with a view to discuss options for adaptation and to provide policy recommendations to mitigate conflicts. To achieve these aims, climate data in conjunction with conflict records is analyzed, supplemented by extensive qualitative field research conducted in 2011 and climate projections. Based on the findings the "Resource Abundance and Scarcity Threshold" (RAST) hypothesis is developed, which could explain contradictory findings between the occurrence of raiding during periods of resource scarcity and during periods of resource abundance. Several options for adaptation to changing climatic conditions exist. Ensuring free and safe pastoral mobility especially across international borders is particularly important. To address the conflicts directly, inter communal conflict prevention and resolution mechanisms need to be strengthened. Failure to mitigate the conflicts increases the vulnerability of the pastoral communities to a warmer and less predictable climate which could lead to more raiding.

6.1 Introduction

In 2011, the Horn of Africa experienced its worst drought in 60 years (United Nations Office for the Coordination of Humanitarian Affairs UNOCHA 2011a). Droughts predominantly affect pastoralists as they are most vulnerable to climatic changes.

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[57] This chapter has been resubmitted (after minor revisions) as Schilling, Janpeter, Akuno, Moses, Scheffran, Jürgen, Weinzierl, Thomas, 2012. On Raids and Relations: Climate Change, Pastoral Conflict and Adaptation in Northwestern Kenya. In: Bronkhorst, S., Bob, U. (Eds.), Climate Change and Conflict: Where to for Conflict Sensitive Climate Adaptation in Africa? Human Sciences Research Council, Durban. As the lead author, Janpeter Schilling is responsible for more than 90% of the chapter's content.

Their vulnerability consists of three elements: climate change exposure, sensitivity and adaptive capacity (Intergovernmental Panel on Climate Change, IPCC 2007b). Climate change exposure is the rate and magnitude of climatic changes that a region is exposed to (IPCC 2007b). In East Africa climate change is characterized by increasing temperatures and higher rainfall variability (Christensen et al. 2007, McSweeney et al. 2008). Both increase the likelihood of more frequent and extended droughts (Few et al. 2006, German Advisory Council on Global Change, WBGU 2008). Sensitivity is “the degree to which a system is affected, either adversely or beneficially, by climate variability or change” (IPCC 2007a:881). Pastoralists in turn are sensitive to climatic changes because their livestock depends on the availability of water and pasture which is negatively affected by climate change. Adaptive capacity relates to available knowledge, skills, options and assets to adapt to climatic changes (see also Adger 2006, IPCC 2007a). While pastoralists have developed their adaptive knowledge and skills over centuries, their options for adaptation and economic assets have been limited by political and socio-economical marginalization (Government of Kenya, GoK 2007, McSherry and Brass 2008).

In Turkana, northwest Kenya, the combination of marginalization and more frequent and prolonged droughts has increasingly overwhelmed the existing adaptive capacity of the pastoral communities (GoK 2008, Mkutu 2008, United Nations Development Programme, UNDP 2011, UNOCHA 2011b). Concurrently, violent conflicts have increased among different groups including the Turkana of Kenya, the Tepeth and Matheniko of Uganda, the Merille of Ethiopia and the Toposa of Sudan (UNDP 2011). These conflicts occur when communities do not settle their opposing views about pasture, water and livestock peacefully but with the use of force (Butler and Gates 2012, Kaimba et al. 2011). The conflicts are closely related to violent livestock thefts (e.g. Eaton 2008b, Eaton 2008a, Witsenburg and Adano 2009). These raids are both a cause and an expression of conflict (Hendrickson et al. 1998, United States Agency for International Development, USAID 2002). On the one hand raids lead to distrust between communities which is a key ingredient for conflict (Mwangi 2006, Schilling et al. 2012a). On the other hand communities express their hostility toward other communities by raiding them (Eaton 2008b, a). These ties between conflict and raiding are not a new phenomenon (Opiyo et al. 2012). However, in recent decades the introduction of small arms has turned the cultural practice of livestock raiding into a deadly and destructive activity (Mkutu 2008, Mwangi 2006).

The parallel occurrence of intensified conflict and prolonged droughts have led to media reports suggesting a direct link between climate change and conflict (for example Guardian 2009). Yet, scientifically, the impact of climate change on conflict in general (see Scheffran et al. 2012d, 2012c) and in Kenya in particular is far from fully understood. Some studies have identified influences of deviations in resource availability on conflict, both related to climate change (Adano et al. 2012, Campbell et al. 2009, Schilling et al. 2011, Witsenburg and Adano 2009) and unrelated to climate change (Meier et al. 2007). Others have attributed conflict to commercialisation of raiding (Buchanan-Smith and Lind 2005, Krätli and Swift 2003), poverty (Omolo 2010), payment of dowry and accumulation of general wealth (Bollig 1993, Hendrickson et al. 1998), retaliation (Eaton 2008a), tribal-based politics (McCabe 2004) and the availability of small arms (Gray et al. 2003, Mkutu 2006).
This chapter purses two aims. First, to analyze potential linkages between climatic conditions and livestock raiding in Turkana. And second, to discuss options for adaptation to reduce the vulnerability to climatic changes. Prior, climate change and its linkages to conflict in Kenya are reviewed in general terms and the methods and case study region are introduced. The last section of the chapter draws conclusions to provide policy recommendations.

6.2 Climate Change in Kenya

Located on the equator, Kenya has a mostly temperate climate in the inland, a semi-arid to arid climate in the northern part and a tropical climate along the coast (Central Intelligence Agency, CIA 2012, McSweeney et al. 2008). The highest temperatures are reached in north Kenya (Kabubo-Mariara 2009). According to the IPCC, temperatures in Kenya have risen by 1°C over the past 50 years (Christensen et al. 2007). Looking particularly at the highlands, Pascual et al. (2006) find a significant warming trend of 0.5°C since the end of the 1970s. This trend is in line with on-ground measurements. Figure 6.1 shows temperature curves from six weather stations across Kenya. The highest temperatures are found in Lodwar which is located in the northern county of Turkana (see Figure 6.1 and 6.3). The entire country is warming at a rate roughly 1.5 times the global average (Christensen et al. 2007). This rate is projected to lead to temperature increase in East Africa of up to

2.8°C until 2060 and up to 4.5°C until 2100 compared to 1900 (Christensen et al. 2007, see also Doherty et al. 2009).

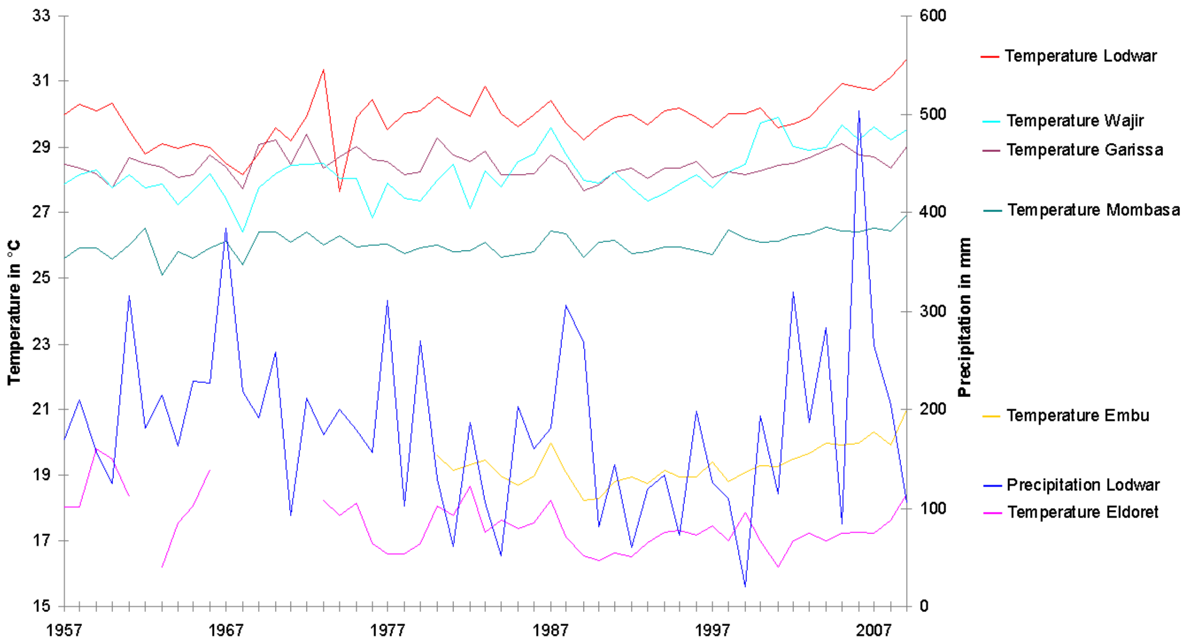


Figure 6.1 Temperature in six towns in Kenya and precipitation in between 1957 and 2009. The locations of the towns are shown in Figure 6.3 (own representation based on data from Royal Netherlands Meterological Institute 2000, Tutiempo 2011)

In terms of precipitation, most of the annual rainfall of about 687mm is recorded during the long rains from March to May and the short rains from October to December (McSweeney et al. 2008). No statistically significant rainfall trend can be observed since 1960 (Figure 6.1 and Eriksen and Lind 2009). However the proportion of rain falling in heavy rainfall events has increased (McSweeney et al. 2008). These heavy rainfall events are projected to occur more often, resulting in a higher total amount of rainfall and an increase of intra- and inter annual rainfall variability (Christensen et al. 2007, McSweeney et al. 2008). The projected rainfall variability for Kenya is illustrated in Figure 6.2 which shows strong precipitation increases in January/February (plot a and g) and precipitation decreases in May/June (plot c and i) until 2050 and 2090.

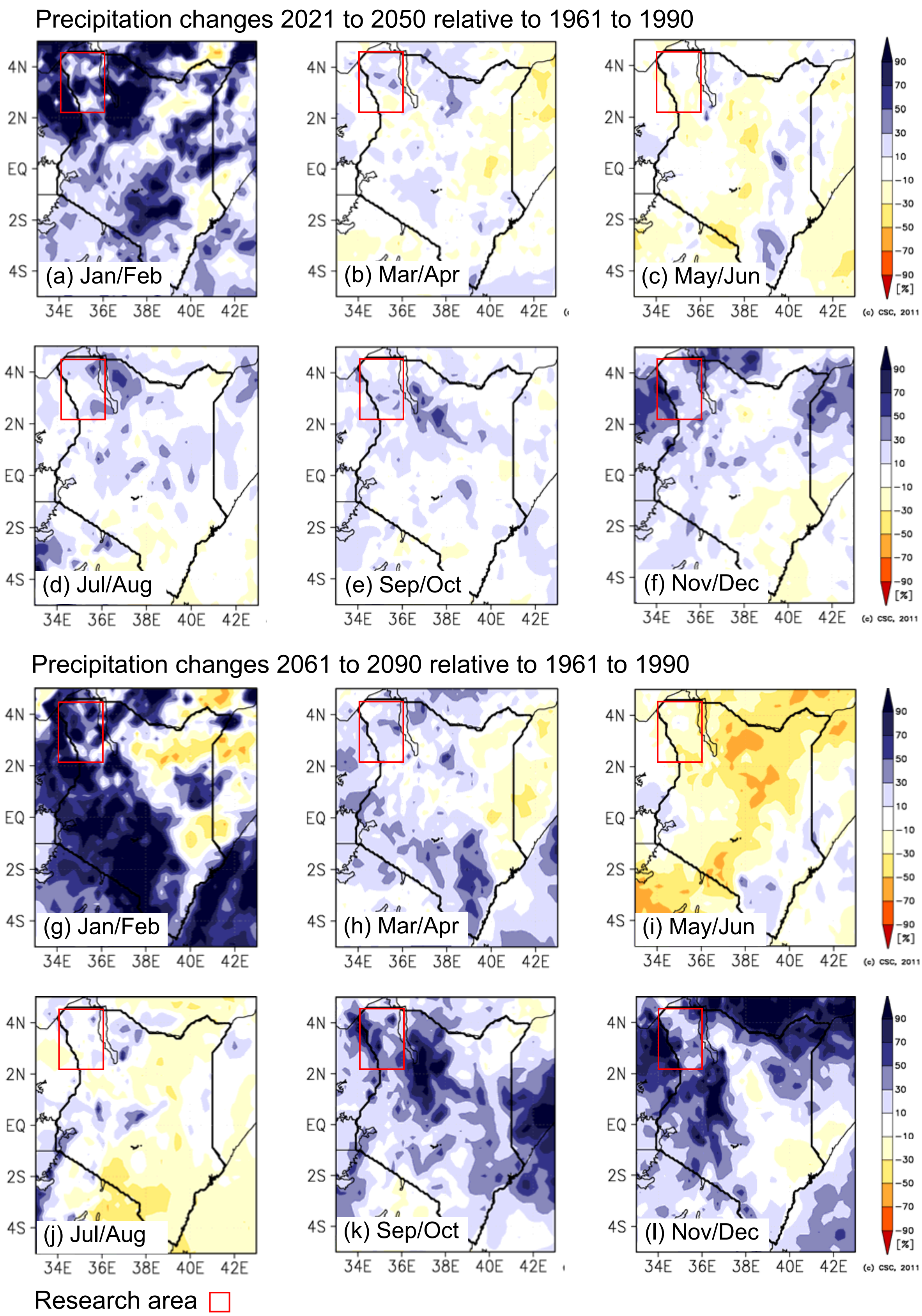


Figure 6.2 Projections of relative changes in precipitation 2021 to 2050 (a through f) and 2061 to 2090 (g through l) compared to 1961 to 1990 in Kenya for two months intervals (Andreas Hänsler 2011). The projections are based on the IPCC emissions scenario A1B (see IPCC 2000). For a detailed description of the modeling method see Hänsler et al. (2011)

6.2.1 Implications of Climate Projections for Pastoral Communities

In general, pastoralists potentially benefit from higher total rainfall amounts as the availability of water for livestock and pasture is increased. However, it does not only matter how much rainfall is received but also when. Strong rainfall events followed by extended dry periods increase the likelihood of floods and droughts, especially in combination with the strong warming trend (Few et al. 2006, Shisanya and Khayesi 2007, WBGU 2008, Williams and Funk 2011). Droughts are not a new phenomenon in Arid and Semi Arid Lands (ASALs), which make up 80% of Kenya's land area (GoK 2007). However the drought frequency has increased. In northern Kenya, where the dryness is most pronounced, 28 major droughts have been recorded in the past 100 years. Four of them occurred in the last decade (Mude et al. 2010). The increased drought frequency gives pastoralists little time to recover from drought-related livestock losses (Huho et al. 2009, 2011, Mude et al. 2010). The increased inter and intra annual rainfall variability decreases the predictability and reliability of precipitation and resource availability. Hence, the projected climatic changes are likely to have mostly negative effects on pastoral communities.

6.2.2 Climate Change and Pastoral Conflicts in Turkana

A number of studies have examined climatic and environmental factors as drivers for conflict in Kenya.[58] Table 6.1 lists the most recent studies and their main findings. Two aspects are particularly evident. First, all studies find a mostly indirect link between climatic and/or environmental factors and the occurrence of violence. Second, two types of studies can be identified: data-based studies which are conducted on national level and empirical studies with a local focus. Further, it is notable that all empirical studies were conducted in predominately pastoralist regions where conflict is closely related to raiding (e.g. Eaton 2008b, Eaton 2008a, Witsenburg and Adano 2009). Two data-based studies also include other types of conflict. Raleigh and Kniveton (2010) focus on communal conflict which for example includes conflict between farmers while Theisen (2012) analysis all conflicts that reach at least 25 deaths in one calendar year.

[58] As climate factors influence environmental factors, both factors are discussed jointly.

Table 6.1 Main findings and statements on the statistical and empirical link between climatic and conflict variables in Kenya since 2007. Page numbers are given in brackets. The column "Link" denotes whether the study found a relationship between the variables (y) or not (n)

Main findings/statements	Link	County/ Scope	Reference
"Climate change is seen as the driving force towards resource competition and consequently resource-based conflict." (516)	y	Kajiado, Machakos	Njiru (2012)
"Climatic factors do influence the risk of conflict and conflict events. I find quite strong evidence for years following wetter years being less safe than drier years." (93)	y	Kenya statewide	Theisen (2012)
"We find a definitive relationship between high rainfall patterns and conflict within Kenya." (15)	y	Kenya statewide	Raleigh and Kniveton (2010)
"Climate change is one of a range of factors causing natural resource scarcity; while natural resource scarcity is one of a range of factors causing conflict." (6)	y	Laikipia, Samburu	Campbell et al. (2009)
"Scarcity, mobility and competition, aggravated by climatic conditions, lead to conflict within and across borders." (16)	y	Laikipia, Samburu, Turkana, West Pokot	Mkutu (2008)
"The data-driven modelling of behaviour has shown that environmental resources can result in disproportionately large variations in the frequency of conflict and cooperation." (7)	y	Mandera	Kennedy et al. (2008)
"More conflicts and killings take place in wet season times of relative abundance, and less in dry season times of relative scarcity" (77)	y	Marsabit	Adano et al. (2012)
"There are three times more killings during rainy season than during the dry seasons. This indicates that in northern Kenya raids-related violence is influenced by climatic fluctuations, which also implies that climate change will have an effect on (in)security." (536)	y	Marsabit	Witsenburg and Adano (2009)
"Deterioration in the climate and environment alone does not lead to conflict, as local populations have learned to adapt to their environments. It is when it is coupled with other social, political and economic factors that exacerbate scarcity that conflicts become more likely." (52)	y	Marsabit	Temesgen (2010)
"Climate change will exacerbate the drought situation, leading to competition over scarce resources and conflicts among resource users." (200)	y	Marsabit, Isiolo	Doti (2010)
"Environmental factors do appear to influence pastoral conflict if only in the influence and constraints they pose to those making the tactical decisions to engage in raids." (733)	y	Turkana, West Pokot, Trans-Nzoia	Meier et al. (2007)
"Climate variability and change have led to increased droughts and floods which have resulted in the loss of animal and human lives, displacements and destruction of property, reduced pasture availability and scarcity of water. This has increased poverty and competition over scarce resources – leading to conflicts, particularly livestock raiding." (98)	y	Turkana	Omolo (2010)
"Vast swathes of Turkana are considered to have a risk of livestock raiding, being most frequent in the dry season when herds are driven to distant borders where grazing and browse is more plentiful." (827)	y	Turkana	Eriksen and Lind (2009)
"This study shows that competition for scarce natural resources aggravated by frequent droughts is central to the violent conflicts witnessed in the study area." (tbd)	y	Turkana, West Pokot	Opiyo et al. (2012)
"Although it may seem logical to suggest that scarcity causes violence, in reality local practice ensures that this is rarely the case." (101) "In the North Rift, raiding tends to fluctuate seasonally, reaching a major peak during the rainy season." (100)	n/y	West Pokot	Eaton (2008b)

Nine of all listed studies (Campbell et al. 2009, Doti 2010, Eriksen and Lind 2009, Meier et al. 2007, Mkutu 2008, Njiru 2012, Omolo 2010, Opiyo et al. 2012, Temesgen 2010) argue along the lines of Homer-Dixon's scarcity theory in which resource scarcity (in the Kenyan context mostly caused by drought) increases the likelihood of violence. The remaining studies (Adano et al. 2012, Eaton 2008b, Kennedy et al. 2008, Raleigh and Kniveton 2010, Theisen 2012, Witsenburg and Adano 2009) find that a higher level of violence is associated with more rainfall and hence increased resource availability.

While Theisen (2012) as well as Raleigh and Kniveton (2010) find a positive statistical correlation between precipitation and violence, Witsenburg and Adano (2009:723, see also Adano et al. 2012) explain that ''raiders like to attack during wet years because of high grass, strong animals, dense bush to hide in and the availability of surface water, which makes it easier to trek with the animals''. Additionally, Eaton (2008b, a) argues that during drought pastoralists cannot engage in raiding as they are too occupied with keeping their own livestock alive.

In summary, climate change altering the resource availability seems to play a role in the occurrence of raiding and conflict, especially in pastoral areas. Yet, the existing theories of resource scarcity and resource abundance provide opposing explanations. This suggests that matters are more complex and that new explanations are needed. After introducing the research area and the methods, the following sections address this need by analyzing the influence of climatic conditions on raiding in Turkana.

6.3 Research Area and Methods

Turkana is located in the northwest region of Kenya which shares international borders with Uganda, South Sudan and Ethiopia (see Figure 6.3). A temperature range between 24°C and 38°C (mean 30°C) and low precipitation levels result in a mostly arid to partly semi-arid climate and a landscape characterized by shrubland, savanna and desert (GoK 2008). The average annual rainfall ranges from about 430mm in the northwest to less than 120mm in the central plains around Lodwar. Most of the erratic and unreliable rainfall is received between March and May (long rains) and between October and December (short rains) (GoK 2008, McSweeney et al. 2008). Besides the major rivers, Turkwel and Kerio, Lake Turkana is the only significant and permanent source of water which suffers from salinization and decreasing water levels (GoK 2008, Kloos et al. 2010).

In addition to the limited and strongly varying resource basis, Turkana has experienced significant political marginalization by the central government in Nairobi which has failed to provide the region with basic services such as access to education and health services (GoK 2007, McSherry and Brass 2008). With a per capita Gross Domestic Product (GDP) of US$171 (UNDP 2006) and a Human Development Index (HDI) of 0.333 (UNDP 2010), Turkana is the poorest and least developed county in Kenya (Omari 2011). Around 75% of the population in the region relies upon food aid for their livelihoods (United States African Development Found, USADF 2011).

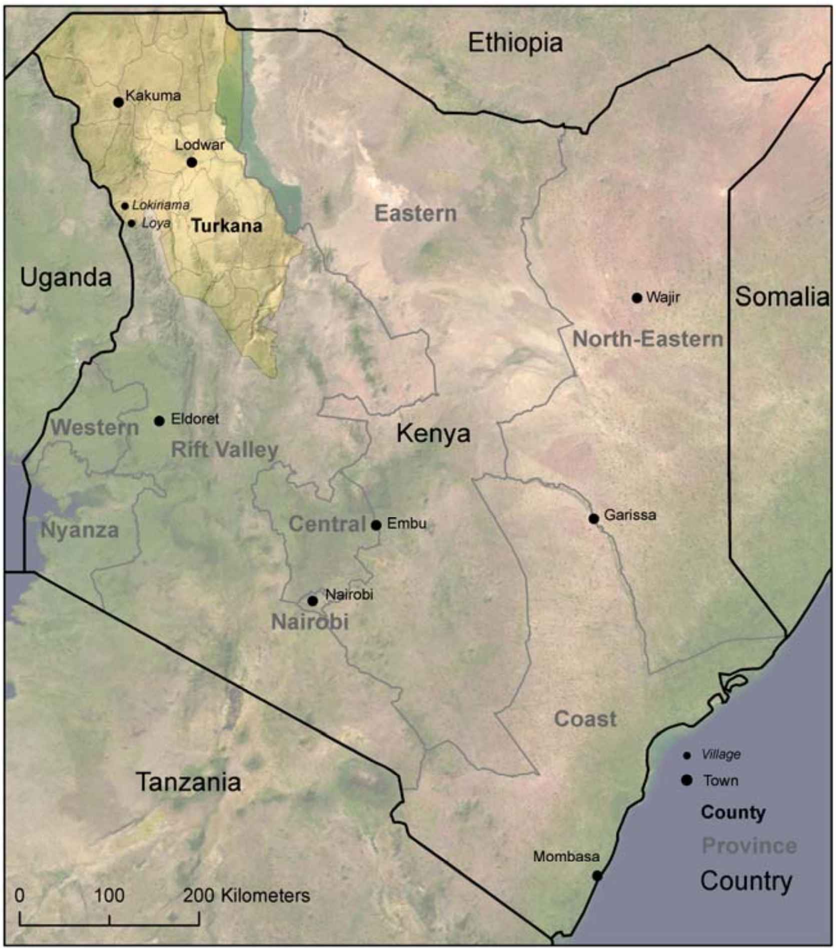


Figure 6.3 Research area Turkana and selected locations in Kenya (own representation based on data from Maplibrary 2007)

Most of the 855 400 people living in Turkana are pastoralists (Commission on Revenue Allocation, CRA 2011, Juma 2009). Besides the Turkana, the county hosts many communities including Dodoth, Matheniko, Pokot and Jie from Uganda, Toposa from Sudan, and Nyangatom and Merille from Ethiopia (UNOCHA 2010a). These groups periodically engage in violent conflicts over resources (Elim and Imana 2011, Mkutu 2006, 2008, UNDP 2011, UNOCHA 2010b, 2011c).

To analyze possible linkages between these conflicts and climate change, a dual method which consists of a qualitative and a quantitative component is applied. One hundred and seventy two persons, including community members (raiders, pastoralists, elders, chiefs and women) as well as representatives of governmental and non governmental organizations (NGOs) were interviewed in Kenya and Uganda in 2011 over a period of 5 months. Most interviews were conducted in and around the villages of Lokiriama and Loya (Figure 6.3). The overall objective of the interviews was to gain an understanding of the raid related conflicts, vulnerability and adaptive capacity of the communities in Turkana and its border region.

The aim of the quantitative analysis was to determine whether any of the linkages between climate change and conflict which were proclaimed by the interviewees, are reflected in the data. To achieve this aim conflict data was analyzed in conjunction with climate data. The conflict data is from the Turkana Pastoralist Development Organisation (TUPADO) incident register which covers raiding incidents in Turkana from 2000 up to today (TUPADO 2011). Raiding in the context of this chapter refers to the mostly violent theft of livestock from one group by another (see also USAID 2002). The analysis is based on the period 2006 to 2009 as the reporting in the remaining years is not consistent. The TUPADO register uses a variety of sources ranging from peace committee members and local authorities (for example, district commissioners and area councilors) to representatives of NGOs and local media (Ekamais 2011). The climate data was taken from the meteorological station in Lodwar, the only synoptic station in Turkana, recording temperature and precipitation values eight times per day since 1919 (GoK 1999). This data was accessed through a public platform which provides daily values since 1957 (see Tutiempo 2011).

6.4 Analysis and Discussion of Climate Change and Raiding in Turkana

Table 6.2 shows the decreasing trend of annual precipitation in Lodwar. The temperature has increased by almost one degree between 2006 and 2009. The number of raids was lowest in 2007 and highest in 2009.

Table 6.2 Annual precipitation, temperature and number of raids in Turkana between 2006 and 2009 (own representation based on data from TUPADO (own representation based on data from TUPADO 2011, and Tutiempo 2011)

	2006	2007	2008	2009
Precipitation (in mm)	503	265	206	105
Temperature (in °C)	30.8	30.7	31.1	31.7
Number of raids	58	31	72	122

The average number of 71 raids per year (six raids per month) reflects the high level of insecurity expressed by the interviewees (Akeru 2011, Akoule 2011, Ekal 2011, Ekiyeyes 2011, Elim and Imana 2011, Locham 2011, Oesterle 2011) and organisations (see also Schilling et al. 2012a, UNOCHA 2010b, 2011c). On average two people died per raid over the four years considered.

To analyze possible linkages between climate conditions and raiding, precipitation and temperature were correlated with the number of raids, the average number of raiders per raid and the number of livestock stolen, finding no consistency in the few higher correlation coefficients (Table 6.3). The only distinctive feature is that in 2006 all precipitation correlations are positive and in 2009 they switch in sign. For temperature, all signs are negative in both years. Yet, overall the values of the coefficients are statistically not significant.

Table 6.3 Correlation between climate and conflict data (TUPADO 2011, Tutiempo 2011)

Correlation of precipitation and	**2006 - 2009**	**2006**	**2007**	**2008**	**2009**
Number of raids	-0,08	0,11	-0,03	0,44	-0,25
Average number of raiders per raid	0,16	0,09	0,68	-0,09	-0,29
Number of livestock stolen	0,00	0,17	-0,18	0,09	-0,39
Correlation of temperature and					
Number of raids	0,16	-0,02	0,14	0,40	-0,57
Average number of raiders per raid	-0,25	-0,32	-0,14	-0,27	-0,12
Number of livestock stolen	0,09	-0,29	0,25	0,05	-0,27

No distinctive features were found when plotting monthly temperature values against the listed set of variables. The analysis therefore focused on precipitation which most strongly determines the availability of water as well as the amount, distribution, and quality of pasture (Birch and Grahn 2007, see also Witsenburg and Adano 2009).

6.4.1 Precipitation and Raiding

Figure 6.4 shows the number of raids per month plotted against precipitation. The years 2006 and 2008 can in part be explained by Witsenburg and Adano's (2009) theory that raiding increases during periods of increased rainfall (see 4.1). Yet, there are several months (January, February, May, June and September of 2006 as well as January and May through September of 2008) without rain while raiding continued.

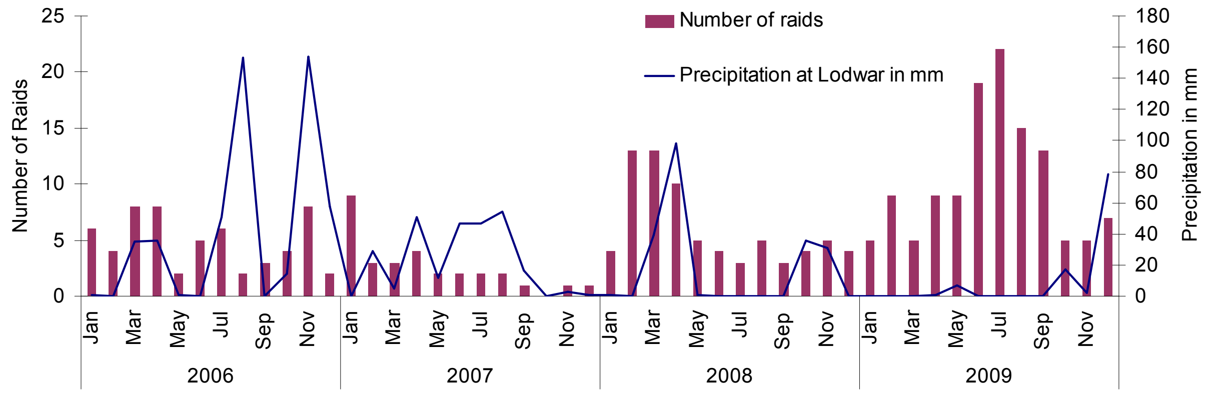


Figure 6.4 Precipitation and monthly number of raids in Turkana between 2006 and 2009 (own representation based on data from TUPADO 2011, and Tutiempo 2011)

The raiding in the months preceding the regular long rains (March to May) and regular short rains (October to December) could be explained by raiders anticipating the rain. “During drought nobody is interested because the animals are dying anyway but when the rains are about to come […] that is the time when those whose livestock has died will want to restock and try to multiply and raid” (Muchai 2011). But even when the momentum of anticipation is included, Witsenburg and Adano’s (2009) “rains and raids” theory does not hold true for the period June through August of 2007 which shows an unusually high level of precipitation in combination with a low level of raiding activity.

The plots of 2009 stand in even stronger contrast to the resource abundance theory. While precipitation was by far the lowest compared to the other three years, the number of raids was by far the highest. This development supports the notion of the resource scarcity theory which identifies the scarcity of resources as a major driver for conflict as previously discussed.

Similar to the opposing findings in the data, several interviewees (Elim and Imana 2011, Kimani 2011) stated that raiding mostly occurs before and during rainy seasons while others stressed that people mostly raid during times of drought (Akoule 2011, Ekal 2011, Locham 2011, Okoro 2011). These interviewees argued that during dry periods raiding is not only used to restock herds but also as a means to secure or gain control over watering points and pasture. In this respect, the two theories of resource abundance and resource scarcity seem contradictory. However, they can be combined in the complementary “Resource Abundance and Scarcity Threshold” (RAST) hypothesis. In regular years with sufficient rain, raiding is mostly conducted before and during the long and short rains to make use of the fortunate raiding conditions (healthier animals, vegetation providing cover, own herds need less attention). But when rains partly or completely fail and a certain threshold of resource scarcity is reached, raids are conducted despite the less fortunate restocking conditions not only to compensate drought related livestock losses but to protect or gain control over scare pasture and water resources. Indeed the hypothesis is based on a limited period of time but it matches the statement of most interviewees who reported that the raiding during rainy season differs from the one in dry season. While the rainy season is used for restocking herds, raiding in dry periods is mainly an instrument to control or gain access over resources. The RAST hypothesis could be instrumental to understand a recent finding by Raleigh and Kniveton (2012). The authors conclude that in East Africa “higher rates of rebel conflict will be exhibited in anomalously dry conditions, while higher rates of communal conflict are expected in increasingly anomalous wet conditions” (Raleigh and Kniveton 2012:51). Here too, the rebel’s effort to gain control over land is strongest in drier periods while the communal conflict, closely related to the violent acquisition of livestock, takes place during periods of increased rainfall. Aside from the possible linkages between climate conditions and conflict, the analysis of the raiding data raises findings related to further developments.

6.4.2 Commercialization of Raiding

The raiding data supports a shift mentioned by the interviewees (Limaris 2011, Locham 2011): the shift from fewer but larger raids (so called “mass raids”) to more frequent raids with a smaller number of raiders (Figure 6.5). This shift is likely to be part of the larger development of commercialization of raiding which refers to “an aspect of the wider integration of pastoralists within a market economy” (Krätli and Swift 2003:8). In other word, the stolen livestock is not used to keep it and to restock herds but to sell it to a trader or directly on a livestock market for cash (Eaton 2010). The practice of commercialization extracts significant livestock numbers from the

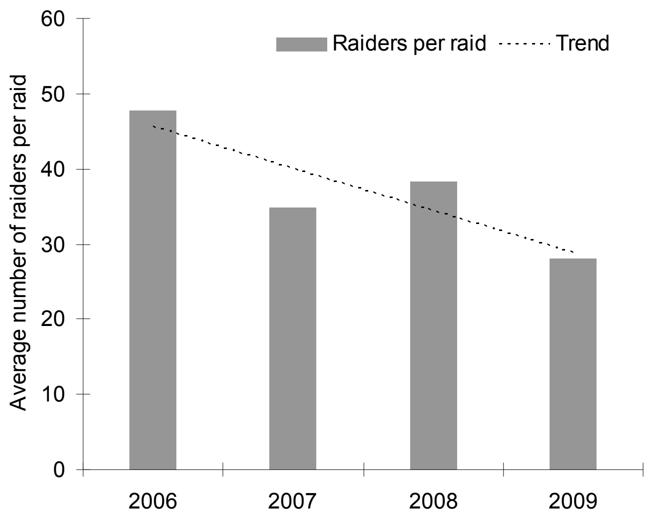


Figure 6.5 Number of raiders per raid in Turkana between 2006 and 2009 (own representation based on TUPADO 2011)

traditional cycle of communities raiding each other to restock (Buchanan-Smith and Lind 2005, Mkutu 2010). Between 2006 and 2009 northwest Kenya experienced a net loss of livestock of more than 90,000 animals in raids (Conflict Early Warning and Response Mechanism, CEWARN 2010).

6.4.3 Small Arms and Raiding

Regardless of the type of raiding, raiding itself is reported to have become more violent (Akeru 2011, Akoule 2011, Ekal 2011, Ekiyeyes 2011, Elim and Imana 2011, Locham 2011, Oesterle 2011). In the period considered here, the number of deaths and injured during raids rose from 139 and 27 in 2006 to 190 and 80 in 2009 (TUPADO 2011). While the cause of death is not listed in the TUPADO register, the ratio between people killed and injured could point to an increased use of semi and fully automatic small arms (see also Mkutu 2008). Most often mentioned in the interviews were G3 rifles and AK47s (Elim and Imana 2011, Limaris 2011, Locham 2011). The arms mostly enter Turkana from Uganda, Ethiopia and Sudan. Fewer are said to come from Somalia (Akeru 2011, Akoule 2011, Kimani 2011). The prices of Ak47s have decreased over the past decades while the price of the bullets has risen.[59] Summarizing the role of small arms in raiding, Joseph Elim from the network of civil society actors Riam Riam stated: “The power is not in the person, the power is

[59] The price ranges for a AK47 bullet differed from 200 to 300 KSH (3,2 USD) (Limaris 2011) to about 50 to 100 KHS (about 1 USD) (Kimani 2011). An AK47was said to cost about 40 000 (about 430 USD) to 70 000 KSH (750 USD) (Elim and Imana 2011).

the weapon" (Elim and Imana 2011). Mukutu even argues that armed raids have replaced "the traditional unity among pastoralists" (Mkutu 2008:148). So far all disarmament efforts have failed and even undermined the communities' trust in the involved governments, as these were incapable of fully disarming all conflicting communities simultaneously and preventing rearmament (Akoule 2011, Knighton 2010, Mkutu 2008, Oesterle 2011, United States Department of State, USDS 2011, Wepundi et al. 2011). If the government of Kenya is incapable of disarming the region, and both climate exposure and sensitivity are beyond the government's control, what can be done to decrease the vulnerability of the region? A promising and practically feasible approach is to strengthen the adaptive capacity of the local population. For this purpose, the next section explores options for adaptation and their implications for vulnerability and conflict.

6.5 Options for Adaptation and its Implications

Pastoralism is a well-suited livelihood for Turkana as it has evolved over centuries and makes efficient use of the erratic and harsh climatic conditions (Birch and Grahn 2007). The traditional response to a decreasing resource base is to expand the existing grazing range and/or adjust the wandering of herds (Omolo 2010). Both imply interaction with neighboring and distant groups. The interaction can have a cooperative character in the form of reciprocal grazing arrangements which can strengthen ties between different groups (Eriksen and Lind 2009). To enable cooperative ties across international boarders, legal agreements with the northern neighbor states are needed to ensure that pastoralists can move freely and safely. In a second step grazing arrangements could be supported by weather forecasts (Luseno et al. 2003) But the expansion of the existing grazing range can also be conflicting, especially when loose grazing associations are formed. In these so called "arumrum", "up to a few hundred households" (Eriksen and Lind 2009:830) come together to enter insecure areas. This often contributes to conflict as other communities perceive it as an "invasion" of their land (interviews with raiders, see also Kaimba et al. 2011).

Further traditional options of adaptation are shown in the upper part of Figure 6.6 (for a comparison with North Africa see Schilling et al. 2012c).

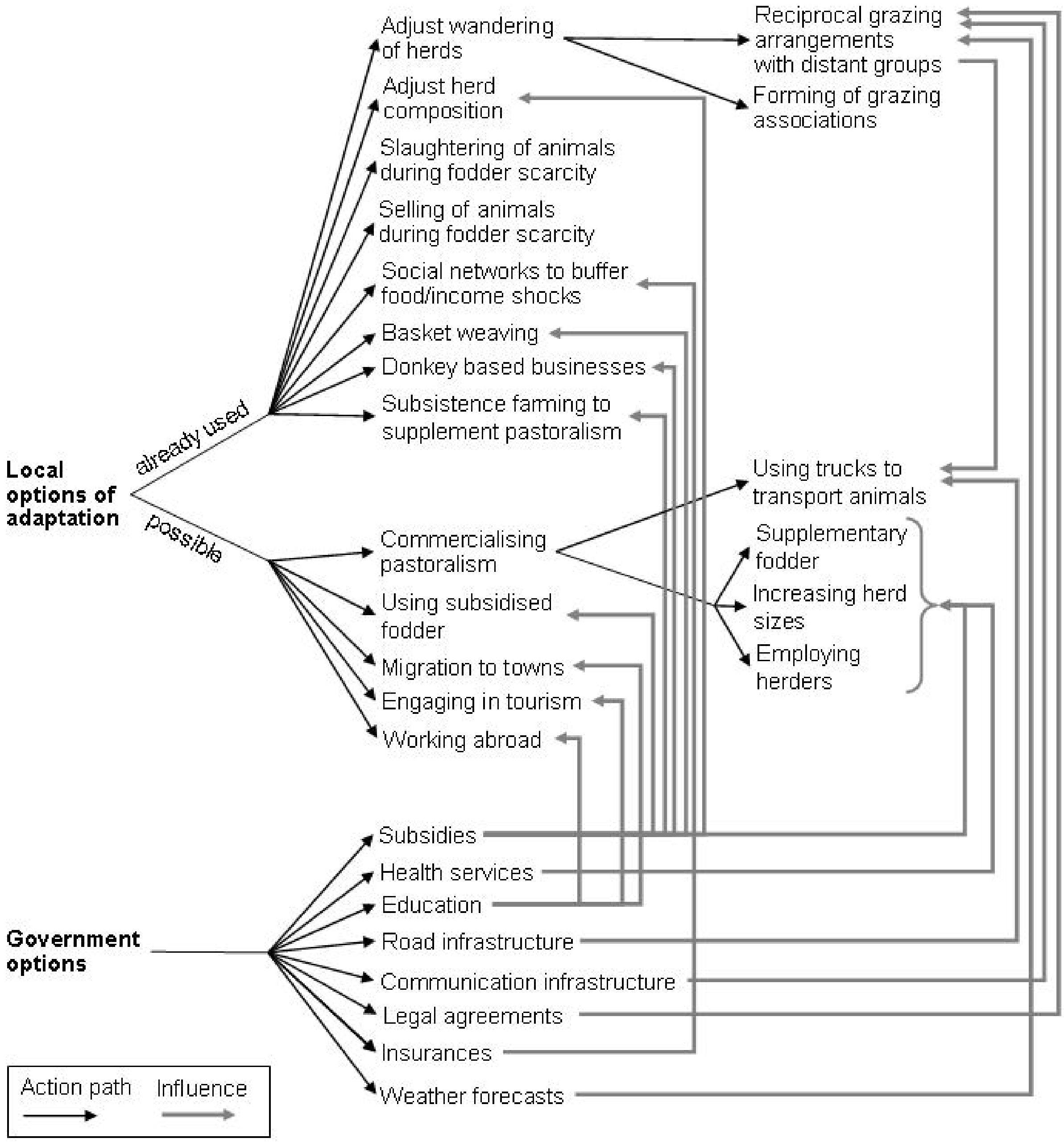


Figure 6.6 Local options of adaptation and government options in Turkana (own representation based on conducted interviews and Eriksen and Lind 2009, Omolo 2010)

The herd composition can be adjusted by replacing cattle with more drought resistant goats and camels (Opiyo et al. 2011).[60] The government could subsidize this shift. In times of fodder scarcity, pastoral communities slaughter their weakest animals as the more healthier ones have a better chance of surviving times of underfeeding (Losike 2011). The government's response to drought has been predominantly to encourage the selling of livestock through large buy-off campaigns (Njiru 2012). On the one

60 For an example of the shift in livestock see Oesterle (2008). Oba (2001b) and McCabe (2004) describe the impact of drought on cattle numbers.

hand this gives pastoralists the opportunity to realize some income with their dying livestock. On the other hand the price offered by the government during droughts is significantly lower than the market price during times of regular fodder availability (Lomali 2011). Hence, the pastoralists loose a significant share of their herd during droughts. Especially when these losses are not sufficiently buffered by social networks (see de Vries et al. 2006, Juma 2009) or insurances (Chantarat et al. 2007), drought can increase the pressure to raid in order to secure the few resources left and the pressure to restock when resources are available again (see previous section).

Especially women can diversify the income sources of a household by weaving baskets or mats (Oba 2001a). However, as only few markets exist in Turkana, the women mainly depend on traders who can to a large extent dictate prices (Eriksen and Lind 2009). Donkeys, usually not used as a food source (milk, meat, blood), offer another income source for women who do not move with the livestock but stay with the young children in villages (Njiru 2012). Here, water, food and fire wood are needed on a daily basis but often not available in close proximity to households. There is potential for women to start a small business based on the transport capacity of donkeys (see Fernando 2002, Ochieng and Wanja 2008). Villagers seeking to transport goods can pay donkey owners for accompanying them with their donkey. This type of small-scale business seems promising in Turkana where the road infrastructure is poor and the use of motorized vehicles is limited. However, it is difficult to ensure that the service is not misused to facilitate the trafficking of small arms and other illegal goods across the porous borders to Uganda, Ethiopia and Sudan.

To a limited extent, subsistence farming and fishing around Lake Turkana is used to supplement pastoralism (e.g. Yongo et al. 2011). In general the diversification of food sources strengthens food security and hence reduces the pressure to engage in conflict over scarce resources. However, in practice the climatic condition in Turkana strongly limit the potential of agricultural efforts. Again, the government could provide subsidies for example for catchment tanks which would enable communities to improve their utilization of the increased rainfall amounts (see previous section). Instead the government has pursued policies which were aimed at transforming pastoralists into pure sedentarized crop farmers (see Homewood 2006). The government itself recognizes that “because such policies were mainly top-down, discriminative and unconsultative, they often failed” (GoK 2007:ii).

In addition to the adaptation options which are already used, further options are possible (centre of Figure 6.6). Given access to subsidies and significant investments in the road infrastructure, a commercialized form of pastoralism is possible. On the one hand this could increase income security and hence resilience of pastoralists (Watson and van Binsbergen 2008, Zaal 2011). On the other hand, the enhanced access to markets may intensify the discussed development of commercialised raiding (Eaton 2010). In addition, the increased herd sizes which are a necessary element of commercialized pastoralism bare the risk of overgrazing and resource depletion (Wasonga et al. 2011). Instead of subsidising fodder for a commercialization of pastoralism the government could subsidize fodder only during periods of drought. This is likely to be more effective in mitigating livestock losses than the current buy-off campaigns (see above).

Migration to urban agglomerations is impracticable simply because there are very few. Within Turkana, Lodwar (48,300 inhabitants), Kakuma (36,900) and Lokichogio (17,700) and are the only towns of significant size (CRA 2011 see also Figure 6.3). In Lodwar the largest employer is the relief sector consisting of predominately international NGOs (Owiti 2007).[61] Likewise, engaging in tourism can currently be considered unfeasible as very few tourists find their way to Turkana mainly because of the unreliable security situation, the lack of sufficient roads and the underdevelopment of tourism infrastructure (hotels, services and attractions) (GoK 2007). Other possible options such as working abroad would require the government to improve the region’s access to education. Remittances sent by youth with a regular income could on the long run strengthen the adaptive capacity of the receiving pastoral community. On the short run, however, children and youth attending schools are missing as labor force to look after the herds and to provide security for the community.

In summary, the government has several instruments to support a variety of adaption options. Yet, each instrument needs to be used carefully to avoid unintended negative outcomes such as weakening of the livelihood bases in the case of large livestock buy-offs during drought periods. Ensuring free and safe movement is most promising as it strengths the core adaptive capacity of pastoralists. But improving the

[61] Among the NGOs are USAID, Merlin, International Rescue Committee UK, Practical Action.

adaptive capacity alone is unlikely to end the raiding, especially when it is not conducted out of vulnerability but for commercial purposes (see previous section). In these cases the “spiral of violence” (Scheffran et al. 2012a) can be interrupted by inter communal conflict prevention and resolution mechanisms. Peace meetings and agreements are key as they are able to stabilize relationships between groups as the peace agreement between the Turkana and the Matheniko has shown for almost 40 years. As part of the European Instrument for Democracy and Human Rights (EIDHR), several peace meetings were held between conflicting parties in northern Kenya. In addition, peace committees in Pokot and Turkana communities were established and equipped with mobile phones to warn other communities about planned raids and to assist with the recovery of stolen livestock. This is important to avoid counter and revenge raids. Obstacles to a timely distribution of information, however, included the lack of sufficient vehicles as well as road and communication infrastructure (Muhereza 2011). This shows how development deficits not only limit the adaptive capacity but also conflict resolution (see also Huchon 2005). Apart from these deficits, Schilling et al. (2012a) stress the importance of involving not only the elders and chiefs in the peace meeting but also the youth as the central conflict actor. In general, a strengthening of traditional institutions, for example the council of elders, is expected to have a positive effects on inter communal relations (Adano et al. 2012, Opiyo et al. 2012).

6.6. Conclusion and Policy Recommendations

The first aim of this chapter was to analyze potential linkages between climatic conditions (temperature and precipitation) and livestock raiding in Turkana. Based on climate and raiding data analysis, qualitative interviews and literature review, the “Resource Abundance and Scarcity Threshold” (RAST) hypothesis was developed. The RAST hypothesis suggests that in regular years with sufficient rain, raiding is mostly conducted before and during the rainy seasons because animals are healthier, they can travel longer distances and raiders find cover for their attacks. But when rains partly or completely fail and a certain threshold of resource scarcity is reached, raids are conducted despite less fortunate raiding condition. Than, raids do not primarily serve the purpose of restocking but rather aim at gaining or securing control over scarce pasture and water resources. Where the threshold between resource abundance (raiding to restock) and resource scarcity (raiding to control resource) lies, is subject to further research. Regardless of the exact transformation from one type of raiding to another, it is important to reduce the vulnerability (exposure, sensitivity and adaptive capacity) of pastoral groups to climatic changes. The climate change exposure, mainly related to increasing temperatures and stronger intra- and inter annual rainfall variability, can hardly be influenced. Similarly, the sensitivity of pasture and water resources to climatic changes is mostly beyond the human scope. Hence, the most influenceable element of vulnerability is the adaptive capacity.

The second aim of the chapter was therefore to discuss options for adaptation and their implications. Several already used and possible options exist which can be supported by a variety of governmental instruments. Mobility is the core element of pastoralism. It is therefore most promising to ensure that the pastoralists can move freely and safely not only within Kenya but also across international borders. Legal agreements between the northern neighbor states Uganda, South Sudan and Ethiopia are needed to prevent harassment of pastoralists by security forces along the borders. It is therefore important to implement the Security in Mobility (SIM) initiative which promotes cooperation between the involved governments to harmonize laws and land tenure systems (Okoro 2011, UNOCHA 2010a, c). Improved security of pastoralists crossing international borders would also contribute to reciprocal grazing arrangements with pastoral groups from neighbor states. Cooperative resource sharing would benefit from an enhanced communication infrastructure. One approach could be through subsidies which can be used to support multiple ways of adaptation to climate change. For examples the government could provide a carefully calculated amount of subsidized fodder to ensure that a higher percentage of livestock survives droughts instead of buying-off animals. Further, it is promising to subsidize catchment tanks which would improve the utilization of the projected increase in annual rainfall. The water would enable pastoralists to start small scale farming which improves food security especially during periods of water and pasture scarcity. However, improving the adaptive capacity alone is not enough because it does not address commercial raids. To stop these raids it is important to strengthen inter communal conflict prevention and resolution mechanisms through the support of traditional institutions and peace meetings. The government and NGOs can facilitate these meetings through the provision of a safe location, transport and food. Failure to mitigate the conflicts increases the vulnerability of the affected communities to climatic changes which in turn could lead to more raiding.

7. Raiding Pastoral Livelihoods: Motives and Effects of Violent Conflict in Northwestern Kenya[62]

Abstract

Conflicts are not new phenomena in many pastoral societies in the Horn of Africa. Traditionally, various pastoral communities have a long history of livestock raids as a cultural practise for restocking especially after periods of drought or disease outbreaks. However, in recent years conflicts related to livestock raiding have become more frequent, violent and destructive. This study was conducted to elucidate first, the motives behind the current livestock raiding and, secondly, to analyze how conflict affects livelihoods of pastoral communities of northwestern Kenya. The study is based on an extensive field research conducted between 2008 and 2011 in Turkana and Pokot Counties in Kenya. Discussions and interviews were carried out with key informants including a sample of 376 community members, administrative officials and non governmental organizations.

The study findings suggest that hunger and drought impacting on resources availability and access are critical for raiding motives among the Turkana while increasing wealth and payment of dowry are the most important for the Pokot community. The violent conflict poses a significant threat for pastoral livelihoods which are already under pressure from a myriad of challenges including recurrent drought, diseases, and political marginalization. The direct impact of violent raiding is felt in terms of loss of human life and property, reduction in livestock numbers, limited access to water and pasture resources, and forced migration. Indirectly, the violent conflicts create a strong and omnipresent perception of insecurity in both communities which entails ineffective resources utilization, reduced access to food resulting in food insecurity, and closures of pastoralist markets, health centers and schools. The present violent conflict destabilizes pastoral communities and undermines their coping strategies, thus contributing to increased impoverishment. Integrating development efforts into a framework of conflict mitigation which address the specific raiding motives of each group is essential.

[62] This chapter has been submitted to the peer reviewed journal Pastoralism as Schilling, Janpeter, Opiyo, Francis, Scheffran, Jürgen, 2012. Raiding Pastoral Livelihoods: Motives and Effects of Violent Conflict in Northwestern Kenya. As the lead author, Janpeter Schilling is responsible for more than 60% of the chapter's content.

7.1 Introduction

Pastoral communities reside in over 21 countries across the African continent. Many of these communities are affected by conflicts, while the Sahel region and East Africa show sustained levels of inter pastoral violent conflicts which have significant impacts on their livelihoods (Bevan 2007). Pastoralism is a major economic production strategy in which people raise herds of animals, mostly in arid and semi arid lands (ASALs). Kenya's ASALs cover about 80% of landmass and support about a third of the country's human population and 70% of the national livestock herd. An estimated 13 million cattle, 25 million goats, 14.9 million sheep, 1.7 million donkeys and 2.9 million camels are found in Kenya's ASALs (KNBS 2010). The highest livestock populations are held by the Turkana and Pokot pastoralists of northwestern Kenya (GoK 2010b). Pastoralism contributes approximately 12% of the country's Gross Domestic Product (GDP) (FAO 2005), with the livestock sector providing an estimated 90% of all employment opportunities and more than 95% of household incomes in ASALs (Kaimba et al. 2011).

Pastoralism practised by the majority of Turkana and Pokot ethnic groups is mainly nomadic and transhumance, which is characterized by risk-spreading and flexible mechanisms, such as mobility, communal land ownership, large and diverse herd sizes, and herd separation and splitting (Opiyo et al. 2012). The livestock types kept by the Turkana and Pokot include cattle (zebu), camels, goats, sheep and donkeys. Livestock possession plays multiple social, economic and religious roles in the livelihood of pastoralist such as providing a regular source of food in the form of milk, meat and blood for household members, cash income to pay for cereals, education, health care and other services. Livestock is also essential for payment of dowry, compensation of injured parties during raids, symbol of prosperity and prestige, store of wealth, and security against drought, disease and other calamities. Livestock is therefore a fundamental form of pastoral capital, besides functioning a means of production, storage, transport and transfer of food and wealth (Behnke 2008).

In northwestern Kenya, pastoral communities have a long history of conflicts closely related to livestock raiding. Traditionally, livestock raiding often involved small-scale manageable violence and theft of the best livestock or replacement of animals lost during periods of droughts or diseases. Loss of human lives was rare, and when this occurred, compensation in the form of livestock was paid to the victims or their families in case of death (Mkutu 2008). The Turkana and Pokot pastoralist have used raiding and violence to restock herds, expand grazing lands, gain access to water and pasture resources, and increase social status for more than 9000 years (Eaton 2008a, Moru 2010). However, in recent years, due to proliferation of modern small arms, commercialization of livestock raiding, dispute over land tenure, banditry and predation, the cultural practice has become a widespread, sophisticated, more violent, and destructive activity among pastoral communities in northern Kenya (Mkutu 2008, Omolo 2010). The proliferation of modern automatic weapons is well documented as having had a negative effect on the scale and impact of armed violence in pastoral communities (Mirzeler and Young 2000, Mkutu 2006). In addition commercialized livestock raiding in which wealthy businessmen, politicians, traders and local people pursue economic objectives has contributed to conflicts among pastoral communities (Eaton 2010, Mkutu 2010). This development interferes with the future and livelihood assets of the pastoralists (Kaimba et al. 2011).

Although violent conflict is one of the greatest challenges that the Turkana and Pokot pastoralist have to deal with, its influence on pastoral livelihoods in northwestern Kenya has not been adequately documented. There have been studies to assess the drivers and mitigation mechanism for the resource based conflicts in the area but it has hardly been possible to analyze the motives and challenges posed by violent conflicts because of the complexity and multi-dimensional character of the conflicts in the region. This study pursues two objectives. First, an agent-based theoretical approach is used to explore why the Turkana and Pokot pastoral communities engage in violent conflicts. Secondly, the study structures and analysis the complex effects of the violent conflicts on pastoral livelihoods. Specifically. the study exemplifies the effects of violent conflict on resource access and utilization, impacts on livestock markets, trade and inter communal relations between the Turkana and Pokot communities of northwestern Kenya. The study shows how conflict contributes to pastoral impoverishment.

7.2 Material and Methods

7.2.1 Study Area

The study was conducted in the southern rangelands of Turkana and northern parts of West Pokot county in northwestern Kenya (Figure 7.1). As part of Kenya’s Rift Valley, the region is characterized by a highly variable and erratic rainfall regime which is bimodal in pattern. The short rains occur between October and November and the long rains between March and May. The erratic rainfall regime is manifested in extreme droughts and floods. Major droughts in the region were recorded in 1969, 1974, 1979, 1980/1981, 1984, 1991/92, 1995/96, 1999, 2004/06, 2009, and 2011 (Huho et al. 2011, Morton 2006). The mean annual temperatures ranges between a minimum of 26°C and a maximum of 38°C, with high evapotranspiration rates (GoK 2008).

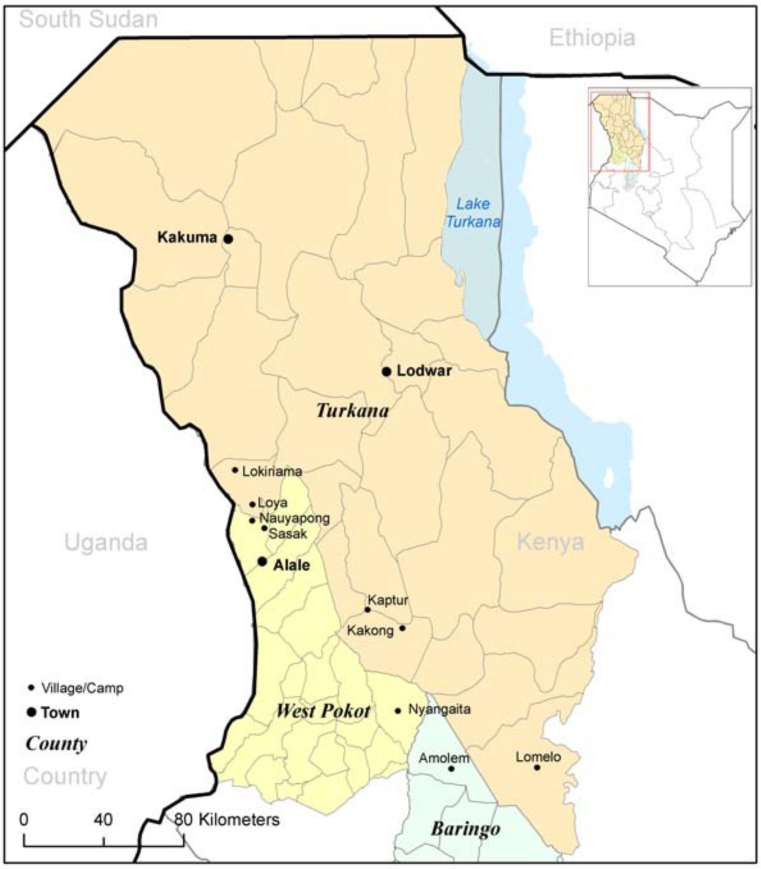


Figure 7.1 Location of the study area in Kenya (Thomas Weinzierl for the authors)

The vegetation mainly consists of scattered *Acacia* bush, annual grassland and herbaceous plants. The density of the woody plants such as *Acacia reficiens* and *A. Mellifera* increases on hilly ground (Mureithi and Opiyo 2010). The study area is characterised by weakly developed soil (Weltzin and Coughenour 1990). Several ephemeral rivers, commonly referred to as *laghas* crisscross the region. Besides the two semi permanent rivers Turkwel and Kerio, Lake Turkana is the only significant and permanent source of water in northwestern Kenya. In addition to the limited and strongly varying resource basis, the Turkana and Pokot region has experienced significant political marginalization which has lead to a lack of basic services such as education, road infrastructure and health services (GoK 2007, McSherry and Brass 2008). Subsistence nomadic and transhumance pastoral production is the main sources of livelihood for the Turkana and Pokot communities in the study area. Some small scale irrigation farming is practiced along river Turkwel and Kerio.

7.2.2 Data Collection

Data collection for this study was carried out between September 2008 and December 2011. Based on a systematic random sampling procedure, interviews and discussions were carried out with a total of 376 persons consisting of community leaders (chiefs, elders) and members (women, pastoralists, youth, raiders). Key informants such as administrative officials, non governmental organization (NGO) representatives and religious leaders were also interviewed individually to explore details on violent raiding motives, conflict trend lines, and effects on the rural livelihoods. A social survey, focus group discussions (FGDs) and interviews were carried out within community clusters in southern Turkana, northern and eastern parts of West Pokot, and in northern Baringo (Figure 7.1). Further, participating and non participating observations were conducted to compliment the data from interviews and FGDs.

Conflict data was analyzed using Excel and the statistical package for social sciences (SPSS). The conflict records were taken from a local NGO Turkana Pastoralist Development Organization (TUPADO) that records raiding incidents in Turkana from 2000 up to 2011 (TUPADO 2011) and from the governmental institution Conflict Early Warning and Response Mechanism (CEWARN) which covers raiding incidents in both Turkana and West Pokot region since 2002.

7.2.3 Theoretical Framework

An agent-based theoretical approach (for an overview see Scheffran et al. 2012b) is used to explore the relationship between the Turkana and the Pokot. The relationship can take two general forms: conflict or cooperation (Figure 7.2). Conflict in this study refers to violent conflict which is understood as the forceful settlement of opposing views about pasture, water and livestock. Cooperation on the other hand relates to the peaceful sharing of resources and a state in which differences are reconciled peacefully.

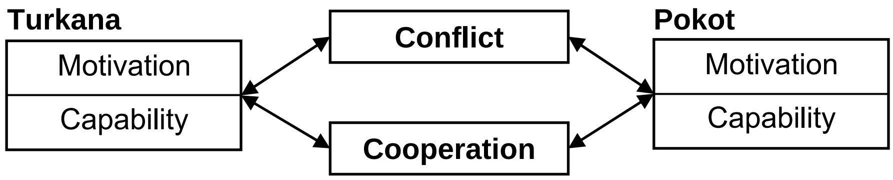


Figure 7.2 Theoretical framework for conflicting and cooperative pathways between Turkana and Pokot (the authors)

Whether the communities choose a conflicting or cooperative path depends on the communities' motivation and capability to realize a certain path. If one element is missing or underdeveloped, the path cannot be chosen.The motivation is the result of the balance between the expected gain and the expected loss of a certain course of action. Livestock raiders for example weigh the likelihood of capturing a significant number of livestock against the likelihood of getting shot, wounded or arrested. For an actor to be motivated to engage in cooperation, the benefits of the cooperation for example in the form of inter community reciprocal grazing agreements have to outweigh the benefits from livestock raiding. While raiding gives raiders an opportunity to realize immediate livestock gains, the raiding also increases the risk of retaliation by the raided community. Cooperation on the other hand improves the security of the cooperating communities but the resource gains in the form of access to water and pasture are mostly realized on the mid to long term.

Capability is usually defined as the ability to execute a certain course of action (Scheffran et al. 2012b). In the context of raiding the capability is mainly determined by the availability of resources, men, weapons, ammunition, skills and information about the target such as the location of herds, types of livestock and level of protection. The capability to choose a cooperative path mainly depends on whether a community is able to establish reliable agreements with the neighboring community.

In theory, both Turkana and Pokot communities have the choice between investing into resource sharing (cooperative path), or pursuing livestock raiding and the destruction of the competitor's capabilities (conflicting path). Yet in practice, Figure 7.2 shows that if one community chooses the conflict path the other actor is almost forced to take this path as well to avoid disadvantages. In general, the overall benefit from mutual cooperation exceeds the one of a conflicting relationship as no resources are wasted for destructive purposes.

7.3 Results and Discussions

7.3.1 Types, Causes and Motives of Livestock Raiding

The Turkana and Pokot ethnic communities have been on a conflicting path for so many decades that respondents were unable to recall a year when they went without raiding and conflicts. In both communities the majority of chiefs, elders, women, pastoralists, youth and raiders stated that the conflict with the other group has escalated in recent years. This finding is in line with other studies which have reported an escalation between the Turkana and the Pokot as well as other communities in northwestern Kenya (de Vries et al. 2006, McCabe 2004, Mkutu 2008, Omolo 2010, UNDP 2011). Regardless of the ethnic community, the majority of people conducting raids are male youth and younger men mostly below the age of 30. Based on the interviews with the communities, three types of livestock raids can be identified according to their number of participating raiders. First, in highly organized "mass raids" several hundreds to even thousand of raiders attack a neighbouring community. Second, in "*Adakar*" raids several dozens and occasionally up to a few hundred raiders from near-by villages come together to raid one village or *Kraal* of a rivaling community. The third type of raids is the smallest with mostly a hand full to less than 15 participating raiders. The targets of the later raids are usually small, unprotected *Kraals* or a group of animals which is only accompanied by one pastoralist or herd's boy.

The majority of the people interviewed suggest that there has been a shift from mass and *Adakar* raids to smaller but more frequent raids. This perception is reflected in the data as the average number of raiders per raid in Turkana decreased from 48 raiders in 2006 to 28 raiders in 2009 (TUPADO 2011). The shift is likely to be the result of two developments. One, improved communication infrastructure which reduces the attractiveness of mid- and larger sized raids and two, commercialization which increases the attractiveness of smaller raids. The improved coverage of mobile phone network, especially in Pokot, significantly increases the chances of the targeted community and administrative authorities to notice and prepare for the planned raid. This in turn decreases the motivation of raiders to participate in a raid as the risk of getting shot by the targeted community or arrested by the administrative authorities is increased. Additionally, the required capability of mid- and larger sized raids is high. Not only does a community have to organize and coordinate a larger number of participants, it also has to know where and when a significant herd can be found and attacked. Smaller raids in contrast require a shorter organization period and hence attract less attention. Here, the risk of getting arrested is smaller. The motivation of raiders to engage in smaller raids is further increased by the development of commercialization. Krätli and Swift (2003:8) define commercialization as “an aspect of the wider integration of pastoralists within a market economy”. This form of raiding is undertaken with the explicit intention of selling livestock for immediate profit instead of kept for restocking own herds (Mkutu 2010). Commercialized raiding is facilitated by improved access to markets, rising demand for meat as part of strong growth of urban populations and improved road infrastructure reaching pastoral regions (Eaton 2010).

Besides the development of commercialization (Buchanan-Smith and Lind 2005, Krätli and Swift 2003) other studies documented a variety of different key factors to explain the phenomenon of livestock raiding among pastoralists in Kenya. The spectrum ranges from poverty (Omolo 2010), payment of dowry and accumulation of general wealth (Bollig 1993, Hendrickson et al. 1998) to retaliation (Eaton 2008a), tribal-based politics (McCabe 2004), institutional set-ups (Adano et al. 2012), availability of small arms (Gray et al. 2003, Mkutu 2006), and climate change related (Adano et al. 2012, Campbell et al. 2009, Schilling et al. 2011, Witsenburg and Adano 2009) and unrelated resource degradation (Meier et al. 2007). Most of the studies agree with Opiyo et al. (2011, 2012) that competition and scarcity of resources in the form of water, pasture, land resources and livestock assets play a key role in the conflicts between pastoral groups.

Results from the present study indicate that the main conflict motives are asymmetric. In Turkana the majority of raiders indicated hunger and drought as their primary and secondary motive for engaging in livestock raiding (Table 7.1).

Table 7.1 Motives for raiding in Turkana and Pokot (the authors)

Primary Motive	**Hunger**	**Wealth**	**Dowry**	**Land**	**Drought**
Turkana	**78%**	22%			
Pokot		25%	**50%**	25%	
Secondary Motive					
Turkana		33%	22%		**44%**
Pokot	25%	**75%**			

In Pokot payment of dowry and accumulation of wealth were the strongest motives. While the results were confirmed by in the FGDs, they are not representative for the entire county of Turkana or West Pokot as the sample was limited to 21 raiders. However, taking into account that raiders are a delicate group to interview, the results help to complete the picture, drawn by the remaining interviews and data analysis. In Pokot, a connection between the accumulation of wealth and commercialized raiding was more pronounced in the interviews with government officials and experts, while raiders denied that they sell a large portion of the captured livestock. In Turkana several representatives of the government and NGO respondents stated that the expansion of Pokot territory into the plains of Turkana and vice versa is one of the central drivers of violent conflicts. Several key informants suggested that this process is politically driven while few indications to support this notion were found during interviews with the communities. Regardless of the degree of political instrumentalization, the demarcation of political administrative boundaries between the Pokot and Turkana grazing range was considered a contributing conflict driver.

The results of this study are not surprising. Omolo (2010) has reported that drought related poverty and hunger can function as strong raiding motives in Turkana. Accumulation of wealth, related or unrelated to commercialization, and payment of dowry have early been identified as raiding motives (Bollig 1993, Hendrickson et al. 1998). However, the presented study shows that conflict parties engage in the same conflict for different reasons. The reasons in turn reflect the resource availability in the research area at the time of the interviews (September to November 2011). West Pokot had received significant rainfall while in Turkana the long rains between March and May had completely failed. Consequently, the Pokot side was rich in pasture, water and animals while the communities on the Turkana side relied almost entirely on food aid as they had lost most of their livestock during the extended dry period. While the motives of raiding differ from group to group, the results suggest that the effects of the conflicts on the livelihoods are similar in both groups.

7.3.2 Effects of Conflict on Pastoral Livelihoods

Conflicts and livestock raiding affect the wellbeing of pastoral communities in various direct and indirect ways. This section attempts to structure and analyze the complex effects by supplementing the results of the present study with findings of previous research. The top of Figure 7.3 lists the motives and causes of raiding as identified previously. The effects of the raiding and conflict are discussed in detail below.

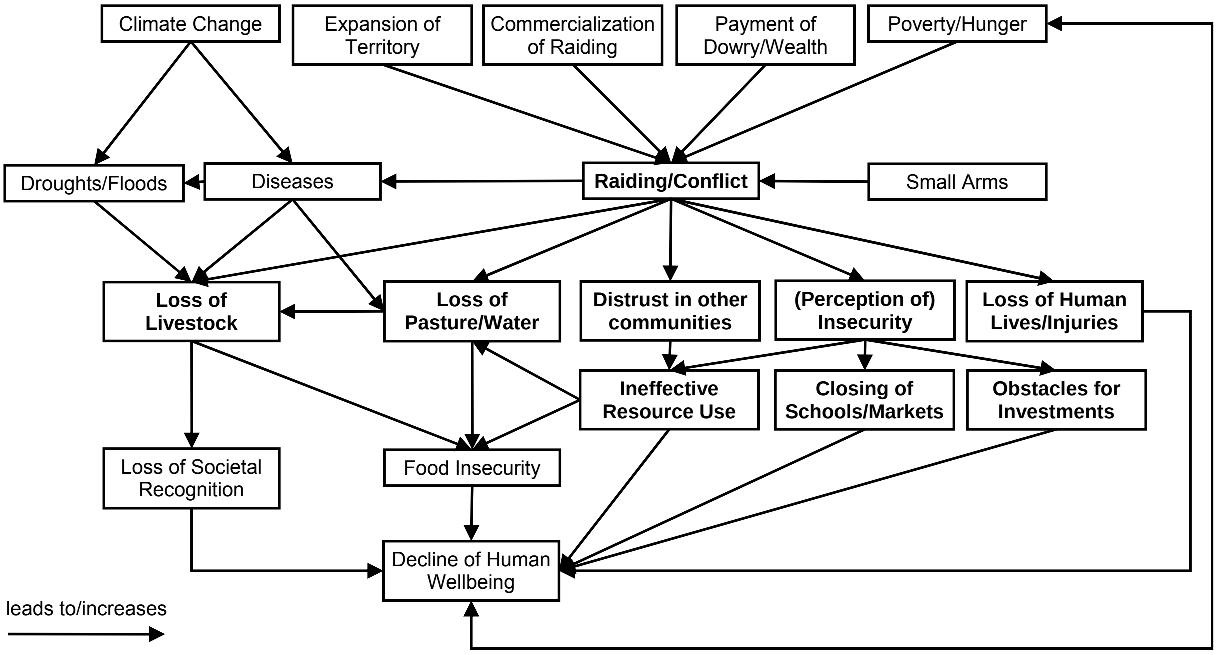


Figure 7.3 Causes and effects of raiding and conflict in Turkana and Pokot (the authors)

Loss of human lives

The most direct effect of raiding on human wellbeing is the loss of lives and injuries caused during the raids. In Turkana alone, TUPADO recorded 592 raid related deaths between 2006 and 2009 (Figure 7.4). For Turkana and Pokot county combined, the governmental institution CEWARN reports a number of conflict related deaths of 640 in 2009 alone (CEWARN 2010). The high number of deaths in relation to the number of injuries indicates that the availability of small arms has made raiding more deadly. Raiders reported in interviews that wounded raiding fellows, especially when unable to walk, are left behind and often shoot themselves to “escape” punishment by the attacked group. Injured and killed raiders reduce the labor available for livestock herding and community protection. As raiders are almost exclusively young men, the raiding does not only affect the community in short terms but also reduces the future prosperity of the community. Beyond the physical impacts of the conflicts on humans, Pike et al. (2010) have documented negative psychological consequences, for example traumata.

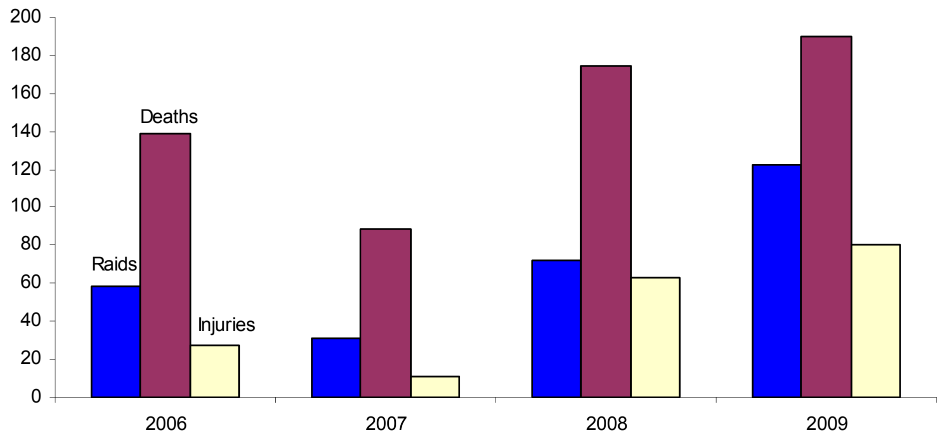


Figure 7.4 Number of raids, deaths and injuries during raids in Turkana between 2006 and 2009 (the authors based on TUPADO 2011)

Effects on Livestock Numbers

Droughts, floods and diseases whether related or unrelated to climate change, frequently reduce livestock numbers in pastoral societies (e.g. Eriksen and Lind 2009, McCabe 2004). While climatic conditions are not influenced by raiding, it contributes to the spread of livestock diseases (Bett et al. 2009, Oloya et al. 2006).

The direct effect of raiding on livestock numbers can be both positive (for the raiding community) and negative (for the raided community). From the raider's perspective raiding can appear to be an effective and direct tool to increase the own herd, at the cost of those who are raided. If two or a few groups in a confined area reciprocally raid each other, the total number of livestock may remain fairly the same.

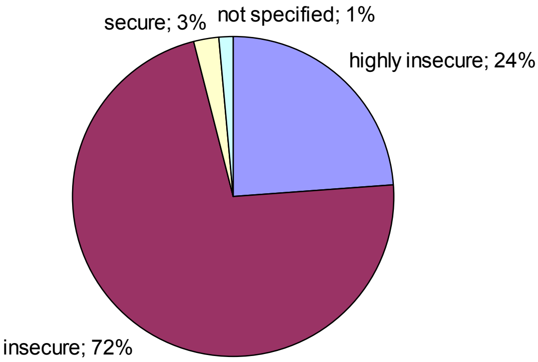
However, the development of commercialization (see previous section) has extracted large numbers from the traditional raiding circle. Turkana and Pokot experienced a net loss of livestock of more than 90,000 animals due to raids between 2006 and 2009 (CEWARN 2010). This number has to be treated with caution as raided communities tend to report higher numbers hoping to receive higher compensations (Eaton 2008a). Yet, the number points to the dimension of losses that some communities experience. During this research interviews 75% of the pastoralists and raiders reported to have lost livestock, partly due to raids and drought related incidences. A reduction in livestock population, even by small numbers, is critical especially for the pastoralists who depend on livestock for income and food insecurity. Similarly, it was reported that loosing livestock also goes hand in hand with the loss of societal recognition and social status. Without livestock young men cannot marry as they are unable to pay dowry. Elders, functioning as communal judges, are suffering from loss of livestock, too. During focus group discussions elders complained that the youth does not respect them anymore. A raider in Pokot North referring to the youth and elders summarized “without cattle you are useless" (see also McCabe 2004). Particularly for women and children the loss of livestock can result in lack of nutrition (Pike et al. 2010, Pike and Williams 2006). Hunger can be both outcome and cause of conflict as the discussion of the raiding motives in Turkana has shown.

Loss of Homes and Resources

The conflict between the Turkana and the Pokot is mostly about livestock raiding which usually takes place in some distance to the villages. However, occasionally bigger kraals and even entire villages are attacked. For example, twenty homesteads were reported to be destroyed and looted between 2008 and 2011 in the conflict corridor between the Turkana and Pokot around Kainuk and Turkwel. In October 2011, the village of Nauyapong was found abandoned due to insecurity caused by Turkana raiders. Only the school staff and the students had remained who were constantly protected by the nearby military camp. The rest of the Nauyapong community had moved south to more secure areas in and around Alale (Figure 7.1). While the abandonment of entire settlements is a rare case, the loss of pasture and water points is a common phenomenon in conflict prone rangelands of northwestern Kenya. Eriksen and Lind (2009) point to the formation of loose grazing associations to expand territory. In these so called “arumrum”, “up to a few hundred households” (Eriksen and Lind 2009:830) come together to take over larger areas with pasture. Watering points are a source of conflict particularly during dry periods. In Lokiriama, several exchanges of gunfire were witnessed between the Turkana and the Pokot who were trying to access the borehole at night. In Lasak and Nauyapong on the other hand, it was reported that the Turkana have recently started to steal maize and beehives because of hunger. Besides the direct loss of resources, the conflicts cause effects which indirectly reduce human wellbeing through insecurity.

Insecurity and its Subsequent Effects

In both communities the perception of pronounced insecurity is omnipresent (Figure 7.5). The larger percentage of interviewees reporting a secure feeling in Pokot, can be explained by the fact that almost 40% of the interviews were from Alale which is a bigger town with stronger governmental presence and hence higher security.



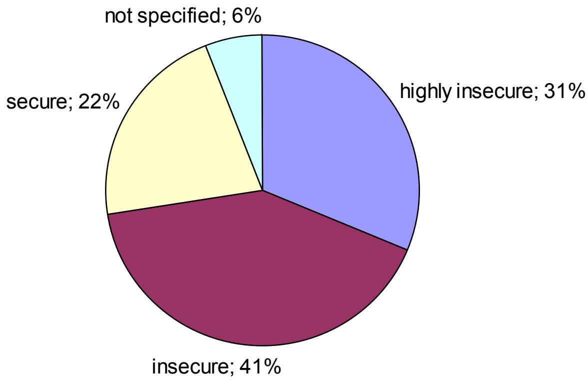


Figure 7.5 Perception of insecurity in southern Turkana (left) and northern Pokot (right) (the authors). In Turkana 63 people were interviewed and in Pokot 49

Insecurity and the perception of it have three major effects which in turn reduce human wellbeing: first, inefficient resource utilization, second closing of markets and schools and third posing an obstacle for investments. Estimates show that between 15 and 21% of northwestern rangelands have become more or less inaccessible to Turkana and Pokot pastoralists, due to enduring inter community ethnic tensions (Morton 2001). The border regions between Turkana and Pokot, for example Lokori, Napeiton, Lomelo, Kappedo, Amaler, Amolem, Nasolot, Sarmach, Turkwel, Lokiriama and Sasak have become increasingly inaccessible. Similarly, it was observed that the rangelands south of Loya (Figure 7.1), located between the Turkana plains and the highlands of Pokot, were rich in pasture. Yet, neither of the two groups was accessing the area because of insecurity. The insecurity is further increased by highway robbery of bandits who take advantage of the power vacuum. Further, the underutilization of pasture bares the risk of encroachment of certain species which deplete the pasture or make it inaccessible (Bollig 1990, Huho et al. 2009, Opiyo et al. 2011). Unused boreholes can dry up as a result of a discontinued use. Along river Turkwel and Kerio, 78% of the pastoralists are forced by conflicts to migrate with their livestock to the neighborhood water sources in Karamoja of Uganda, while 10% are confined within the few safe river banks that remain. This concentration of people and livestock increases the likelihood of overuse of resources and poses a potential source of new conflict. The majority of respondents reported that they are afraid to move freely when conflicts are ongoing in the study area. Similarly, Kaimba et al. (2011) find that livestock raiding interrupts the mobility strategies of pastoralists in

Kenya. As insecurity limits pastoral mobility which is an integral part of pastoralism, insecurity limits pastoralism. But not only pastoralists are affected by insecurity. Women in Lokiriama, Lobei and Urum reported that they have reduced the picking of wild berries because they are afraid to get killed or raped. This shows how insecurity undermines adaptation to climatic changes as the picking of wild berries was reported to be an important coping strategy during extended dry periods.

The effects of insecurity on pastoral livelihoods go beyond a reduction of food resources. Livestock markets in Lokiriama and Loya are not used because of insecurity. The lack of secure markets limits the ability of the pastoralists to sell livestock prior to or during dry periods and hence contribute to food insecurity (Barrett et al. 2003, Juma 2010, Speranza 2010). During the three years of this study, Turkana reported that options to sell livestock to traders were limited as these were afraid of attacks on their way to Kitale or Nairobi. Influx of grains and manufactured goods into Pokot and Turkana was also reported to be negatively affected by insecurity. The schools in Lokiriama and Lobei were temporarily closed when conflicts intensified, as teachers reported. Bullet holes in school buildings were still visible. Insecurity does not only interrupt education, it also poses an obstacle for development. Today, Turkana is the poorest and most marginalized county in relatively rich Kenya (see study area in Figure 7.1). For example, the construction of the road between Lokiriama and Lorengipi was stopped as the security of the construction workers could not be assured.

Beyond the physical effects, insecurity negatively affects the inter communal relations. Community members of both Pokot and Turkana have expressed strong negative feelings and distrust towards the other group. The distrust decreases the motivation and the capability of the communities to choose a cooperative path which is a prerequisite for peacefully and effective resources sharing (Eriksen and Lind 2009). Inter communal relations particularly deteriorate when raids include the rape or abduction of women. This practice could increase the incentive for parents to marry off their daughters early into the “safe hands” of a husband (see Little et al. 2009). Another response to such hostile attacks is retaliation which further fuels the conflict (Eaton 2008a).

7.4 Conclusions and Implications

The aim of this study was to understand the motives behind the raiding and to analyze the effects of the conflict on pastoral livelihoods. The major conflict motives are asymmetric. On the Turkana side the reduction in pasture, water and livestock has made raiding the only survival alternative other than relying on food aid. Consequently, hunger and drought were identified as the main motives for raiding. On the Pokot side where pasture and water was available at the time of the research, the accumulation of wealth, payment of dowry and the expansion of territory are found to be the strongest motives for raiding.

Among the most direct effects of the raiding are loss of human lives, loss of livestock as well as loss of water, pasture and even homes. In addition, the conflicts lead to distrust in other communities and a strong omnipresent perception of insecurity which entails several and partly interconnected subsequent effects. These effects include ineffective resource use, closing of markets and schools, and obstacles for investments. In combination with droughts, diseases, small arms and, social, political and economic marginalization, the effects of raiding pose a significant threat for pastoral livelihoods. In fact, one could argue that the conflicts are “raiding pastoral livelihoods”.

Against this background, there is a need for effective conflict mitigation that breaks the cycle of violence, retaliation and impoverishment. While Opiyo et al. (2012) have recently discussed this question in detail, some general conclusions can be drawn from this study. To move from the conflicting to a cooperative path one could start by addressing the capability of the actors. In theory, disarmed groups cannot cause as much harm as armed groups. However, as governmental disarmament efforts of the past were selective and poorly coordinated, they predominantly failed, partly creating power disequilibria (Mkutu 2008, Wepundi et al. 2011). Given the high availability of small arms in the region, it is more promising to address the motivation of the actors by decreasing the attractiveness of raiding and increasing the attractiveness of non violent alternatives that increase the capabilities in cooperative activities. Hence, increasing the level of development as suggested by Kaimba (2011) is theoretically a useful instrument to decrease raiding as it provides the youth with opportunities to engage in alternative livelihoods, for example paid labor. However, investments in formal education are also problematic as for instance young men who attend school are unable to look after livestock at the same time. The lack of labor is likely to further decrease the survivability of traditional pastoralism. Hence, development alone will not be purely beneficial to pastoral livelihoods, especially because conflict is a major obstacle to investment as our study as pointed out. Instead, any investments in development in northwestern Kenya need to be embedded into a framework of conflict mitigation which offers incentives for both conflict parties to simultaneously leave the conflict path and to invest resources into cooperation. The incentives need to address the specific raiding motives of each group. For the Turkana, this would imply to improve food security beyond the provision of relief food. Interim fodder supplies for example would ensure that a larger percentage of livestock survives periods of drought. On the Pokot side the commercialization of raiding could be addressed by prosecuting the traders as suggested by Eaton (2010).

8. Resource-based Conflicts in Drought-prone Northwestern Kenya: The Drivers and Mitigation Mechanisms[63]

Abstract

The theory of "resource scarcity" dominates the debate on "ecoviolence" in pastoral areas, where conflicts among communities have traditionally been linked to competition over scarce resources and invariably drought because of its role in resource depletion. However, the notion that climate change and resultant resource scarcity directly prompt violent conflict has been challenged by the notion that conflict actually coincide with periods of resource abundance. These contesting views point to nondeterministic linkage between resource availability and conflicts and, therefore, the complexity of pastoral conflicts. This is the scenario hypothesized for the vast pastoral areas of Kenya where violent conflict has become a chronic characteristic. While focusing on drought-induced conflicts over grazing resources, this paper takes cognizance of other factors that trigger and perpetuate violent conflicts in arid northwestern Kenya. We present an insight on the nature, causes, dynamics and mitigation strategies of conflicts between the Turkana and Pokot pastoralists based on research study focusing on the linkages between resource availability and conflict. The findings suggest that violent conflicts in pastoral areas result from a myriad of socio-cultural, economic and political factors that reinforce one another by limiting availability of, depleting and reducing access to natural resource base. Competition for scarce natural resources triggered by frequent droughts and exacerbated by weak local institutions, proliferation of small firearms, political incitements, unclear property right regimes and cattle-raiding, was considered central to the violent conflicts observed in the area. The authors conclude that developing integrated policies and strengthening local governance institutions that are rooted in traditional practices for managing resources and inter community conflicts is integral to the solution.

[63] This chapter is accepted for publication in the peer reviewed journal African Journal of Environmental Science and Technology as Opiyo, Francis, Wasonga, Oliver, Schilling, Janpeter, Mureithi, Stephen, 2012. Resource-Based Conflicts in Drought-Prone Northwestern Kenya: The Drivers and Mitigation Mechanisms. As the lead author, Francis Opiyo is responsible for the majority of the chapter's content. Janpeter Schilling has contributed about 30% to the chapter's content, particularly to the sections on causes and mitigation of conflict.

8.1 Introduction

Classical conflict studies have typically focused on traditional deterministic causal models dominated by the ‘resource scarcity’ theory, often overlooking or ignoring other ethnic, cultural, economic, and political dimensions which are equally important. However, the contesting opinion that links conflict with periods of resource abundance challenges this original and popular hypothesis of ‘ecoviolence’. These opposing views compound the ideology of conflict and exemplify the complexity that surrounds violent conflicts among pastoral communities in Africa. Climate change, one of the biggest challenges of the 21st century, not only presents an extra challenge in coping with pastoral conflicts but also in understanding the complexity at their roots. The high climatic variations observed over the past few decades increase risks and uncertainties that threaten the well-being of most rural communities that depend on natural resource-based livelihoods. Climate variability manifests in extreme events notably droughts and floods, which have increased in frequency and severity over the past three decades (IPCC 2007b). Prolonged periods of drought[64] are now a regular occurrence across sub-Saharan Africa, especially in arid and semi-arid areas (ASALs) inhabited by pastoral communities, whose main occupation is livestock rearing. An analysis of climate variability in Africa between 1900 and 2100 by Hulme et al. (2001) showed that climate variability and change is not a phenomenon of the future, but one of the relatively recent past, as the continent is warmer and drier than it was 100 years ago. According to the IPCC fourth assessment report (IPCC 2007b), global mean surface temperature is projected to increase by 1.5°C - 6°C by 2100, accompanied by changes in precipitation patterns and increased frequency of extreme weather events. The length of crop growing period over the Horn of Africa is expected to decline by 5 - 20% in 2020 and over 20% by 2050 (Magda et al. 2009, Thornton et al. 2006) with implications for crop and pasture productivity. These trends are, due to their direct effects on natural resources, likely to have negative effects on the majority of rural households that rely on crop- and livestock-based livelihoods. By causing resource scarcity, extended dry periods have the potential to catalyze resource-based conflicts in pastoral areas, where grazing resources are shared among communities (Eriksen and Lind 2005). The central premise of conflict theory is that, as individuals and groups in a society

[64] Drought as used in this context refers to deficiency in rainfall in a region over extended period of time, usually a season or more, leading to shortage of water thereby causing adverse impacts on vegetation, animals and people (WMO 2006).

compete to maximize their share of the limited resources, the struggle inevitably leads to conflict. Edossa et al. (2005) observed that most of the conflicts arose when customary practices are no longer viewed as legitimate or consistent with national policies, or when entities external to a community are able to pursue their interests, while ignoring the needs and requirements of the 'insiders'. Conflicts, therefore, emerge from inequalities in accessing or controlling resources (Wasonga et al. 2010). In the absence of strong local institutions, when pastoral groups struggle to maximize their share of the limited grazing resources, especially during droughts, competition and conflict may arise. By triggering scarcity and deprivation, drought therefore may not only cause conflict but also compromise livelihoods (African Union 2010). Resource scarcity, therefore, has the potential to drive society into a self-reinforcing spiral of violence, institutional dysfunction, and social fragmentation (de Soysa 2002a). Several studies (Blench 1996, Haro et al. 2005, Mkutu 2007, Moru 2010, Oba 1992, Witsenburg and Adano 2009) focusing on drought and violent conflicts have been conducted among pastoralist communities inhabiting the drylands of East Africa. The findings attempt to explain the linkages between drought and conflict prompted by depletion of natural resources and competition over access. While numerous factors trigger social unrests in pastoral areas, extreme weather events compound the already complex scenario.

Understanding of drought as a factor in resource-based conflicts is therefore, critical in the pastoral areas given the increased rainfall unreliability associated with climate change. In Kenya, an analysis of rainfall data from the ASALs reveals widespread droughts in 1960/1961, 1969, 1973/1974, 1979, 1980/1981, 1983/1984, 1991/1992, 1995/1996, 1999/2000, 2004/2005, and 2008/2009 (Huho et al. 2011, Morton 2006). The current decline in water and pasture resources in Kenya's ASALs have been linked to recurrent and prolonged droughts (Morton 2006). The ASALs of Kenya cover approximately 84% of the country's landmass, support 30% of the human and 70% of the livestock population, and employ about 90% of the local population (GoK 2007), with the majority being pastoralists who depend directly on livestock-based livelihoods. Despite their contribution to the national economy, pastoral areas in Kenya are plagued with a number of problems including poverty which is associated with livelihood insecurity due to resource degradation and scarcity, as well as the accompanying resource-based violent conflicts.

Over the years, pastoralists have lost thousands of livestock due to droughts (Huho et al. 2011). Drought, range degradation and conflict are interlinked by complex reinforcing mechanisms that make them destructive to both resources and pastoralists' well-being. A study by Macharia and Ekaya (2005) shows that land degradation reduces viability of pastoralism and directly contributes to increased vulnerability of pastoral households to food insecurity. In addition, range degradation has indirect potential effects of prompting ethnic tensions over shared resources in the absence of strong local institutions and inter community resource sharing arrangements (Berger 2003). Arid northwestern Kenya, inhabited by several pastoralist communities that share resources under a unique and complex tenure, presents a great potential for persistent violent conflicts in the absence of functional resource governance institutions. Besides the Turkana and Pokot communities, the region provides common dry and wet seasons grazing ground for various ethnic groups that comprise the Samburu from northeastern Kenya; Jie, Matheniko, Tepeth, and Dodoth from northeastern Uganda; the Toposa and Jiye of southeastern Sudan; and Nyangatom (Dongiro) and Merille from southern border areas of Ethiopia (Dyson-Hudson and McCabe 1985). The Turkana and Pokot pastoralists who form the majority of the inhabitants in the area have a long history of traditional cattle raids, and inter ethnic conflicts over the scarce resources (McPeak et al. 2005). In the recent years however, cattle raiding has become more violent, sophisticated, indiscriminate and destructive, thereby fuelling ethnic violence in northern Kenya (Buchanan-Smith and Lind 2005, KHRC 2010, Mkutu 2007, Omolo 2010).

Studies by Berger (2003) and Moru (2010) show that drought periods correlate positively with increased incidences of ethnic conflicts, which together determine pastoralists grazing pattern in northwestern Kenya. When insecurity is high, livestock herds tend to concentrate in small secure grazing zones, leaving large tracts of land along the borders between communities unused. Estimates by Morton (2001), show that between 15 and 21% of northwestern Kenya remain insecure and therefore inaccessible each year. This is attested by the abandoned dry season grazing areas on the territorial borders between the Turkana and Pokot; Turkana and Karamojong of Uganda; Pokot and Karamojong; and the Pokot and Samburu communities of northern Kenya. However, as observed by Okello (2005), pastoral conflicts are not adequately explained by resource scarcity theories alone but also by the dynamics of cooperation and co-optation within communities, as well as the theories of economic and political ecology. Due to the inadequate presence of state security apparatus in pastoral areas, owing to their vastness and remoteness, most pastoralists acquire illegal firearms for self-protection, hence compounding the problem and creating a conducive environment for criminals to engage in commercialized livestock raids. The commercialization of cattle rustling has also been linked to loss of livelihoods and poverty among pastoral communities that drive unemployed young men, for whom there are limited economic opportunities, to engage in raids. As indicated by Buchanan-Smith and Lind (2005), powerful and well connected businessmen and politicians are at the centre of commercialized raiding in northern Kenya. The illicit firearms used in the raids reach Kenya from conflict prone neighbouring countries such as southern Sudan, Somalia, Ethiopia and northern Uganda (Kumssa et al. 2009). The proliferation of the small firearms is already a great security concern in the larger northern Kenya and is slowly affecting communities neighbouring the region. The Government's disarmament efforts have, however, been unsuccessful because they are often ill-informed and never tailored to address the underlying conflict causes (Moru 2010). A similar government approach was reported by Krätli (2010:4) in the neighbouring Karamoja region in Uganda, which the author describes as "system-blind measures that focus on disarmament and punishment thereby exacerbating rather than reducing the violent conflicts".

Despite the dire need for intervention, the enactment and strengthening of appropriate strategies to support pastoral livelihoods is slow. Nonetheless, pastoralists have survived natural and human-induced stressors for centuries through traditional institutions and coping strategies (Mworia and Kinyamario 2008, Opiyo et al. 2011). These strategies include raising a variety of livestock species, mobility, communal land tenure, keeping large herds, herd splitting, informal social security systems, forming economic alliances with non pastoral communities and engaging in non pastoralist activities like farming and trade (Nyariki et al. 2005, Wasonga 2009). However, the current vulnerability of pastoral households to drought and recurrent resource based conflicts add to the weakened customary institutions and ineffective pastoral coping strategies that predispose pastoral livelihoods to various stressors. A downscaled understanding of the nature and causes of pastoral conflicts and their interaction with climate variability, among other driving factors, is critical not only in designing appropriate mitigation measures but also in achieving sustainable resource management and secure pastoral livelihoods. This study was, therefore, conducted to identify and analyze the central drivers of and potential mitigation strategies for the conflicts between the Turkana and Pokot pastoralists in northwestern Kenya.

8.2 Material and Methods

8.2.1 Study Area

The study was carried out in conflict prone border areas of Turkana and Pokot Counties in northwestern Kenya (Figure 8.1). The study area is a typical semi-arid rangeland falling within agro-climatic zones IV and VI, where managing short-term climatic fluctuations as well as adapting to long-term changes is critical in sustaining livelihoods. The climate is generally hot and dry throughout the year, with mean annual temperature varying from 28°C - 41°C.

Figure 8.1 Study areas in Turkana and Pokot Counties, Kenya (the authors)

Rainfall is unreliable and erratic in both space and time, and is bimodally distributed within the year with the long rains falling from April to May, and the short rains from September to October. The average annual rainfall ranges from 120 mm in the East to over 200 mm in the northwest parts of the region. Seasonal rivers (*laghas)*[65] and streams are the main sources of water for both domestic and livestock use in the study area. The major seasonal rivers are Kerio and Turkwel that drain the border regions of Turkana and Pokot counties. Other sources of water in the area are sandy riverbeds, shallow wells, earth dams, weirs and bore holes. Under the precarious environmental conditions that characterize northwestern Kenya, pastoralism is the most sustainable land use system because it is based on a strategic resource use pattern that is cognizant of the spatial and temporal ecological heterogeneity of the rangeland ecosystem.

8.2.2 Data Collection and Analysis

This paper is based on two pillars of extensive field research: the Drought Mitigation Initiative (DMI) project and a doctoral thesis focusing on the linkages between resource availability and conflict. The DMI project, led by Vétérinaires Sans Frontières-Belgium (VSF-Belgium), developed and implemented community resource use plans and inter community reciprocal grazing agreements as strategies for mitigating resource-based conflicts.

The study covered 10 mobile pastoralist villages namely: Lokwamusing, Elelea, Kakongu, and Kaptur in Turkana county and; Amolem, Nyangaita, Amaler, and Tikit in Pokot county. Data collection within the DMI project was conducted between August 2008 and December 2010. The fieldwork involved focus group discussions (FGD) and key informant interviews with herders, elders, raiders, opinion leaders, local provincial administrators and officials of development agencies working in the study area. Eight FGDs, each comprising 20 - 25 persons of different gender and age groups sampled from each village, were conducted. In order to answer the research questions, data collection focussed on livestock grazing movements, resources availability, conflict causes, livestock raiding and mitigation strategies. Other sources of information included informal discussions with government officials, development agencies workers and local leaders, and direct observations in the field. Data collection for the doctoral thesis was conducted in March and between September and December 2011 in the southern Turkana and the northern West Pokot regions. Individual interviews using semi-structured questionnaires and FGDs were used to

[65] Laghas are dry water ways or seasonal river beds that are important water sources for livestock and humans.

gather data from 166 persons, including community members (raiders, pastoralists, elders, chiefs and women), as well as representatives of governmental and non governmental organizations (NGOs). The questionnaires were group specific but had a common set of core questions designed to understand the main drivers of the conflict and potential mitigation measures. The FGDs were further used to explore issues which turned out to be contradictory during the interviews. In addition to the field data, secondary information from various governmental agencies such as Conflict Early Warning and Response Mechanism (CEWARN) and NGOs such as Turkana Pastoralist Development Organization (TUPADO) was synthesized and incorporated. The data was analyzed within and across groups using the statistical package for social sciences (SPSS) to generate descriptive statistics.

8.3 Results

8.3.1 Human and Livestock Population Characteristics

The Turkana (72.8%) and Pokot (27.2%) were the main ethnic groups in the study area. Lokwamusing, Elelea, Kakongu and Kaptur Divisions in Turkana South district had a human population of 23,828 persons, while Amolem, Nyangaita, Amaler and Tikit Divisions that form Pokot Central district had 8,881 persons. The average population density was 12 persons per km^2 and 61 per km^2 for Turkana South and Pokot Central districts, respectively (GoK 2010a).

However, it was observed during the study period that, these figures are subject to constant fluxes given the nomadic nature of communities living in the region. Frequent population influctuations from other areas into Kangitit, Lopii, Lomelo, Napeitom, Kamuge, Akiriamet, Nasolot, Sarmach, Kainuk and Masol areas that lie at the border of the territories of the Turkana and Pokot communities was reported during the study. The livestock species kept, average household herd sizes and livestock populations for Turkana South and Pokot Central are summarized in Table 8.1. The livestock types include cattle, sheep, goat, camel and donkey. In both the Turkana and Pokot pastoral communities, goats were the most dominant species in the household herds followed by sheep, and cattle.

Although the overall livestock population was found to be higher in Turkana than Pokot community, the highest margin was observed in the camel population, with the Turkana holding over 99% of the estimated herd size in the region.

Table 8.1 Estimated livestock population in Turkana South and Pokot Central districts (the authors)

Type of livestock	Turkana South		Pokot Central	
	Mean household[66] herd size	Total number of livestock	Mean household herd size	Total number of livestock
Cattle	24	685,832	16	479,212
Sheep	59	1,682,418	25	746,300
Goats	100	2,846,748	67	1,513,141
Camels	15	412,577	1	1,050
Donkey	10	273,686	6	6,559

The livestock population in the study area was reported to follow spatial and temporal fluctuations in human populations occasioned by mobility.

8.3.2 Livestock Grazing Movements

Information obtained from the elders and herders indicate that livestock mobility is the main strategy used by the Turkana and Pokot pastoralists to cope with climate related risks and uncertainties associated with resource fluctuations. During the dry seasons, the Pokot herding itineraries begin at their traditional homelands on the west over to the neighbouring areas of Turkana South district, then towards Samburu district and back to their territory after the rains. During the dry seasons in Nyangaite and Ngaina, the Pokot move their herds towards Masol hills where they graze for two to three months before proceeding to Chepaywat towards the onset of rains. Between January and March, they move the herds from Chepaywat and Ngaina to Lotongot in Amolem. In case the onset of the long rains in April is delayed, the herds take two main routes; some through Sarmach, Turkwel, Kainuk, Nakwamuru and Kaptir, while others move to Lomelo, Napeitom, Silale, Longewan and finally to Suguta valley. During the wet seasons in April-June and October-December, the herders from Turkana South graze their livestock in Katilu, Kaptir and Lokichar while the herders from Turkana East graze towards Lokori, Katilu and Lochakula (Figure 8.2). During the long dry season (January – March), both the Turkana and Pokot move towards the dry season grazing areas at the shared border. It is at this time that conflicts normally arise as the two pastoral communities compete to take control over grazing resources.

[66] A household was defined as the basic unit of livestock ownership, where first-level decision-making is made on livestock management such as grazing route and enclosure maintenance. Herding is, however, done collectively within *arum-rum* (highly mobile camp or village whose location is determined by, among other factors, availability of water, pasture and security).

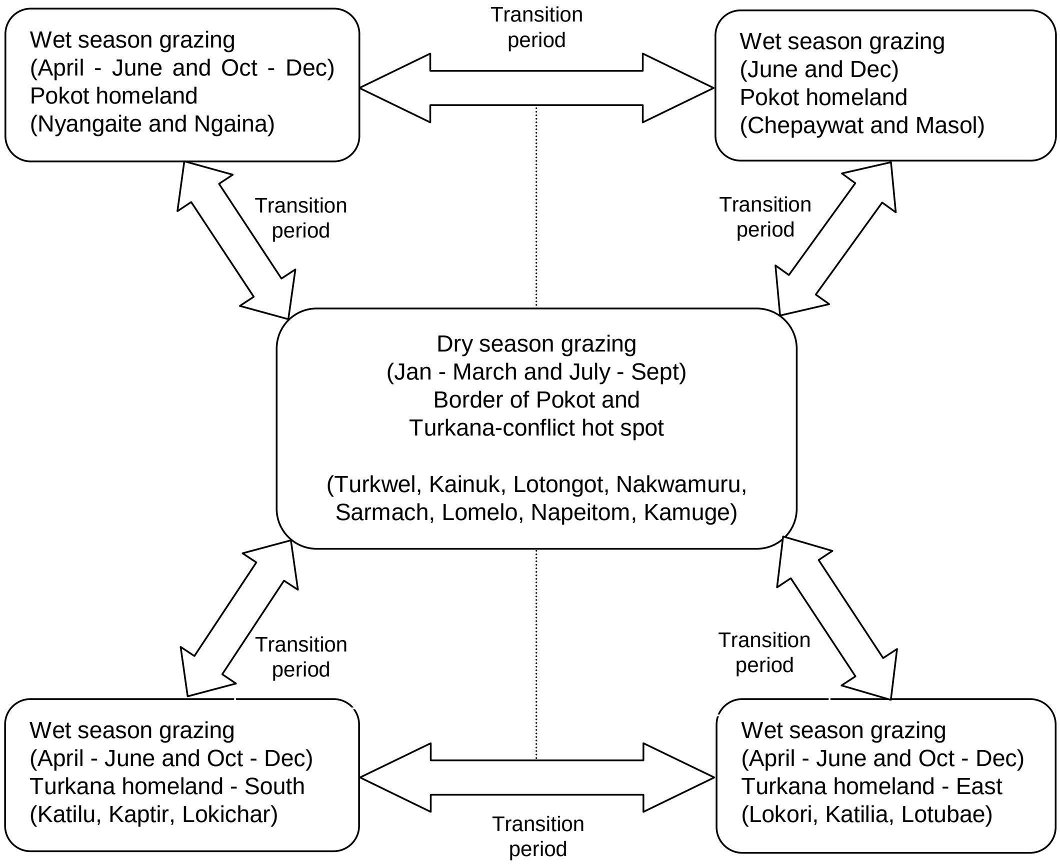


Figure 8.2 Grazing pattern of the Turkana and Pokot herds (the authors)

8.3.3 Resource Availability and Pastoral Conflicts

The results show that pastoral conflicts occur mostly during the dry seasons when key resources (pasture and water) are scarce (Table 8.2).

Table 8.2 Causes of conflict and raiding motives in northwestern Kenya (the authors)

Causes of conflict	**Raiding motives (ranked by importance)** Turkana South	Pokot North and Central
1. Cattle raiding 2. Territorial control and tenure claims over key resources 3. Unclear land rights and government policies 4. Political incitements 5. Proliferation of small firearms 6. Weak presence of state security machinery 7. Ethnic polarization and historical rivalries	1. Hunger / poverty 2. Drought / lack of pasture and water 3. Payment of dowry 4. Defending / expansion of territory	1. Payment of dowry 2. Wealth accumulation 3. Defending / expansion of territory

Due to insecurity arising from such conflicts, most of the grazing lands in the dry season grazing areas remain under-utilized, implying that livestock herds are confined to smaller and drier areas and thereby potentially contributing to rangeland degradation. The abandonment of the critical dry season grazing areas have negative ecological impact as the un-grazed lands lose productivity due to bush encroachment and invasion by undesirable and unpalatable species that replace key forage species (Krätli and Swift 2003).

8.3.4 Community-based Conflict Mitigation Strategies

Selection of the planning committees was found to be an important factor in the formulation of a successful resource use planning. Involving the communities in the selection of the planning committees fosters ownership, community cohesion, ensures equity and enhances sustainability of resource use plans. During the planning process, livestock herders, local authorities, administration officials as well as local political leaders were identified as the lead stakeholders in the range use planning process. Other stakeholders included the county council and government institutions such as the Ministry of Lands, and Ministry of State for Development of northern Kenya and other Arid Lands. Building capacity of resource use planning committees and the target communities was found to be a prerequisite for successful conflict mitigation planning processes, as well as a vital tool in reinforcing the agreed grazing practices. Multi-stakeholder participation, collaboration and consensus building between the planning committees and key players were reported to be indispensable for a successful land use planning and conflict resolution. Interviews with key informants in the sampled villages revealed that the community leaders together with local public and informal institutions are currently responsible for land and other natural resources related decisions. One important lesson learnt from the project is that range resource use planning should be carried out at ecosystem level rather than basing it on specific administrative boundaries. This is because pastoralists and their herds are mobile and ecosystems and livestock grazing resources transcend the administrative boundaries. It was reported that after developing participatory land use plans, it became necessary to institutionalize the negotiated reciprocal grazing arrangements as one way of further minimizing the resource competition and conflicts between the Turkana and Pokot pastoralists.

Table 8.3 presents the strategies proposed by communities to mitigate resource-based conflicts, the envisaged benefits and challenges for their implementation. In order to minimize resource use conflicts during droughts, there is need to strengthen the existing local institutions mandated to implement the land use plans; develop the inter communities resource use plans; encourage inter community dialogues and experiential learning; and promote alternative livelihood strategies that are compatible with pastoralism.

Table 8.3 Strategies proposed to mitigate drought-induced conflicts in northwestern Kenya (the authors)

Suggested interventions	Potential benefits	Challenges
Development of inter community resources use and grazing management plans	Organized and sustainable resource use, enhanced mobility and access to pasture and water	Ethnic polarization and, frequent and prolonged droughts make it difficult to follow the grazing plans
Strengthening of existing customary conflict-resolution mechanisms	Enhanced acceptability, ownership and sustainability of established grazing plans and inter community conflict resolution mechanisms	Weak or absence of local institutions and failure of the state to recognize the role of customary institutions in conflict resolution
Development of inter community reciprocal grazing agreements between pastoral communities	Enhanced mobility, access to grazing resources and peaceful sharing of resources across territorial boundaries	Absence of effective customary institutions and increased ethnic polarization and political incitements
Resolution of the disputes over administrative boundary in the interface land of the Turkana and Pokot communities	Increased access to dry season grazing land and reduced disputes over resource ownership and access rights	Weak or absence of local institutions and lack of community involvement by the state in demarcation of administrative boundaries and, ethnic animosity and political incitements that deter consensus
Strengthening of state security presence in the conflict hot spots	Improved security leading to increased mobility and access to dry season grazing, minimal cattle raids and conflicts	Inadequate state personnel, infrastructure and ill-informed government approach to pastoral conflicts
Mainstreaming of communal land tenure in the national land policy	Devolved resource governance and secure land rights that enable enforcement of customary resources use regulations leading to sustainable resource management	Weakened local institutions and lack of appreciation of traditional resource governance systems by the decision makers
Promotion of exchange visits and interaction between communities	Increased inter community dialogues and experiential learning and, strong inter community social alliances	Political incitements, ethnic animosity and lack of financial resources required to facilitate exchange programmes
Promotion of alternative livelihoods activities that are compatible with pastoralism	Diversified asset portfolios that complement livestock-based livelihoods and, therefore cushion pastoral households from diverse impacts of drought and other shocks	Little effort by the state to commit resources for developing and promoting viable alternative livelihoods and, limited choices of viable activities in the drylands besides livestock rearing

Equally emphasized was the need for local institutions' representatives to work jointly on procedures of maintaining peace in the shared grazing areas, as well as creation of by-laws to govern resource use.

8.4 Discussion

8.4.1 Mobility and Herd Diversification

In-depth discussions with the key informants revealed that herd mobility is one of the key strategies used by the Turkana and Pokot pastoralists to cope with climate related risks and uncertainties associated with resource fluctuations. Under normal circumstances, each community in northwestern Kenya has its own grazing territory over which they have an exclusive right of access. In addition, they traditionally acquire secondary rights to neighbours' territories through the principle of reciprocity especially during droughts. The constant fluctuation of human and livestock populations reported in the study area attest to the inter territorial herd movements. Whereas herd movements are restricted to each community's own territory, protracted droughts normally lead to inter territorial movements, which in the absence of prior resource sharing agreements, trigger clashes among communities over key resource areas (Mureithi and Opiyo 2010). Despite the frequent conflicts, insecurity, droughts, disease outbreaks, and cattle raids that disrupt their grazing patterns, the Turkana and Pokot herders follow relatively well-defined seasonal grazing routes.

Besides mobility, rearing of mixed-species herds is another coping and risk management strategy employed by pastoral households to optimize the use of heterogeneous ecosystem and meet different socioeconomic obligations. Livestock species have different uses, feeding preferences, levels of physiological and behavioral adaptation, and tolerance to environmental stressors. Therefore, keeping a herd of mixed species is necessary for exploitation of the different ecological niches and the animals' complementary adaptabilities, as well as for meeting social and economic needs. The higher population of sheep and goats (collectively referred to as shoats) was partly attributed to their drought tolerance and socio-cultural roles.

In addition, shoats can be readily sold for cash to meet basic needs of pastoral households. The large disparity observed between the Turkana and Pokot camel herd sizes can be explained by cultural preferences. Customarily, the Pokot do not keep camels but have in the recent past adopted camel keeping because of its drought tolerance and disease resistance. The Pokots' shift to rearing of camels is an adaptation to the increasing frequency and severity of droughts in the recent past, a strategy that underscores the flexibility of pastoral production systems in response to a changing climatic conditions and environment.

8.4.2 Resource Availability and Conflict Nexus

The positive correlation between resource scarcity and conflict corroborates the findings of Aredo and Ame (2004) and the environment-conflict paradigm, which suggests that unfulfilled needs for scarce water and pasture fuel conflict between pastoralist groups (Homer-Dixon 1999, Suliman 1999). In contrast, other studies (Butler and Gates 2012, Theisen 2010, Witsenburg and Adano 2009) show that cattle raiding in Kenya escalates during the wet seasons. Witsenburg and Adano (2009) correlated monthly rainfall data with cattle raiding data from 1960 – 2006 in the Marsabit district of northern Kenya and found that wetter years had more than twice (50) as many people killed in violent raids as compared to drier years (23). They associated this trend to the opportunistic behavior whereby raids increase when there is need to restock after a devastating dry spell, when livestock are stronger to walk long distances and healthier to fetch better prices and when there is enough bush cover for the raiders. As indicated by Schilling et al. (2011), raiding in the months preceding the long rains (March - May) and short rains (October - December) could be explained by raiders anticipation of favorable conditions for herd re-building after dry season losses. However, in their analysis to determine the relationship between climate and raids in the study area, Schilling et al. (2011) found no clear correlations between the number of raids and the level of precipitation (Figure 8.3).

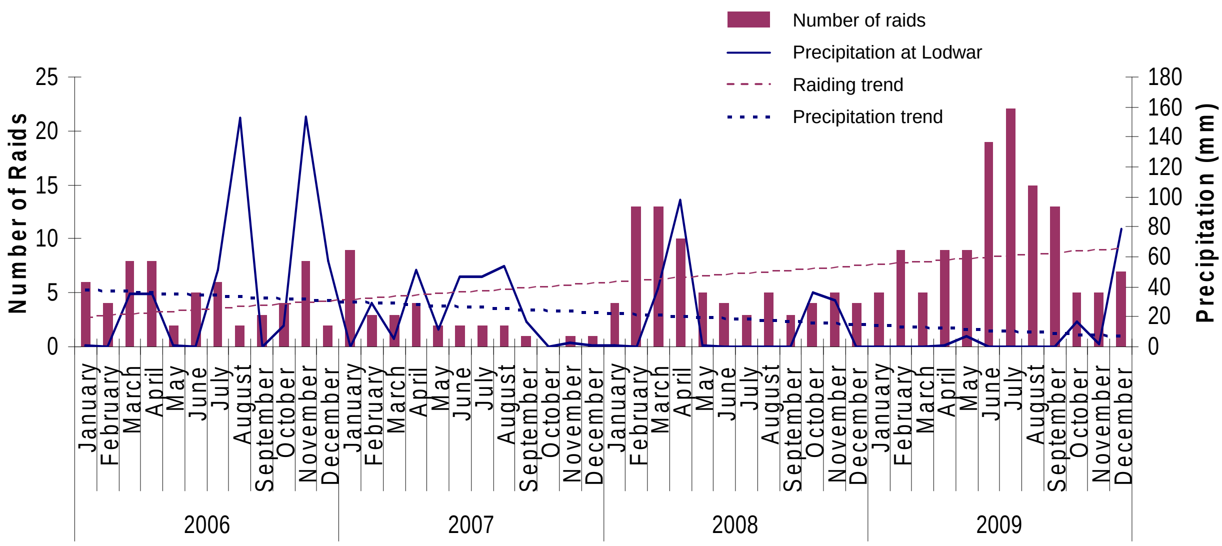


Figure 8.3 Precipitation and number of raids in Turkana between 2006 and 2009 (Schilling et al. 2011)

This is contrary to a study by Meier et al. (2007), who reported a positive correlation between pasture abundance and the frequency of raids in the borderline areas of

Uganda, Kenya and Ethiopia Using analytical framework of a Contest Success Function (CSF), Butler and Gates (2012) corroborate the findings of Meier et al. (2007) but point out that the positive correlation between conflict and resources abundance is contingent on property right regime. They argue that, in the absence of property rights, individual resources can be allocated either to production or to appropriation. The cattle-raiding trend in northwestern Kenya can be attributed to a case where the actors chose to allocate their individual resources to appropriation as opposed to production. However, more contrary findings bring to the fore the contest between the theories of "resource abundance" and "resource scarcity". As observed by Witsenburg and Adano (2009), the high correlation between raids and pronounced drought of 2009, challenges the generally accepted assumption that during severe drought periods, water and pasture is shared peacefully.

One explanation for the contradictory findings on the relationship between raiding and climatic conditions can be that there are different types of cattle raiding, which may overlap time. Generally, there are two types of raiding: First, raiding to acquire livestock either for restocking or commercial purposes (Figure 8.4).

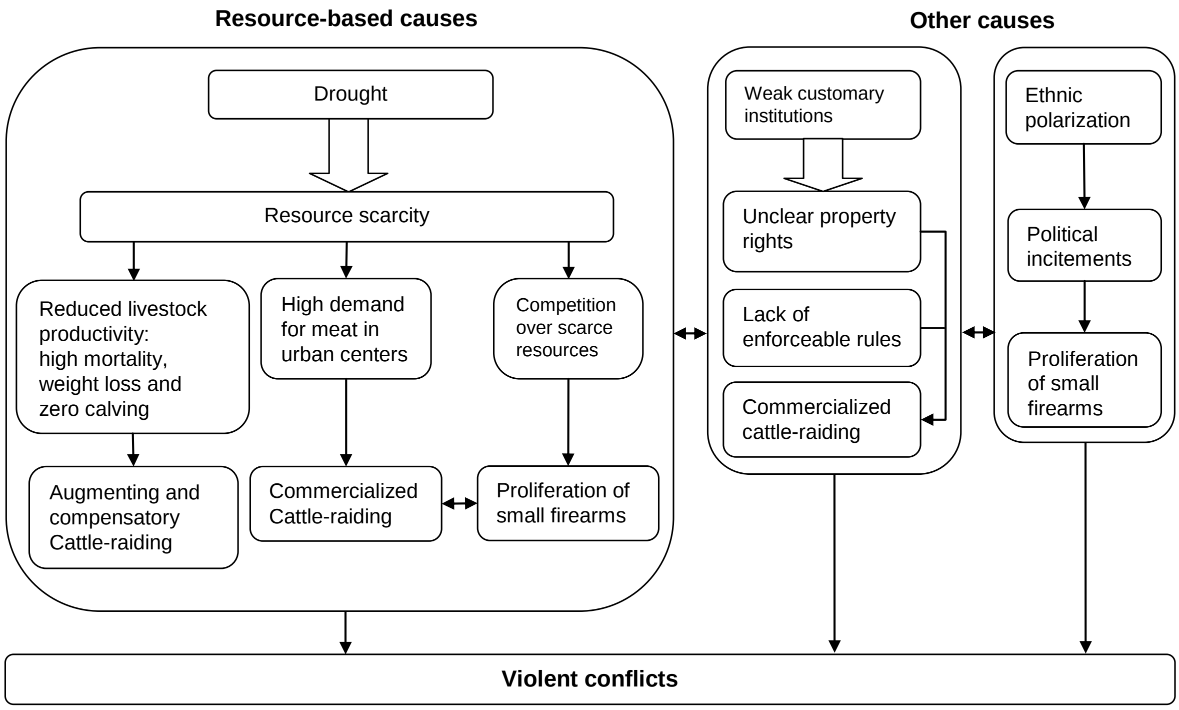


Figure 8.4 Typology of violence among pastoral communities (the authors)

This type is mostly conducted just before and during the long and short rains in anticipation of favorable conditions for herd re-building (Schilling et al. 2011, Witsenburg and Adano 2009). The augmenting and compensatory cattle raiding is an integral part of pastoral culture in Africa, mainly used to acquire livestock for restocking purposes after losses due to drought, raiding and death, and to meet customary obligations such as payment of dowry and, as a rite of passage for young men into manhood. Such raids are traditionally sanctioned by elders and governed by customary values (Kumssa et al. 2009). However, the current form is a departure from the traditional one and has been commercialized due to improved access to markets because of growth of urban populations and infrastructure close to pastoral regions (Bevan 2007). In contrast, the second type of raiding is used as a means to gain or secure control over critical resources (Mkutu 2007). This type of raiding is higher during the dry season as suggested by the findings of this study.

In view of the foregoing logic, it is apparent that cattle raiding, a major source of violent conflicts in pastoral areas occurs during the dry periods as well as in the rainyseasons. This, therefore, suggests that the two contesting resources-based theories apply not as discrete scenarios but in a “resource abundance resource scarcity” continuum, thereby creating nondeterministic relationship between resource availability and pastoral conflicts. Schilling et al. (2011) explain this scenario using the concept of “Resource Abundance and Scarcity Threshold” (RAST), which hypothesizes that, in case the rains partly or completely fail, a certain threshold of resource scarcity is reached that triggers raids regardless of the prevailing unfavourable restocking conditions. The deterministic relationship between resource scarcity and violent conflicts is however, rare to non-existent under pastoral set up due to customary institutions that foster relations between neighbouring and distant pastoral communities, for example, through reciprocal resource sharing. It is therefore, in the absence of strong traditional institutions and existence of external interference (extreme climatic events and unfavourable Government policies) that violent conflicts thrive (Figure 8.4). Berger (2003) highlights some of the potential pastoral conflict drivers such as, natural resource scarcity, competition, ethnic polarization and poverty.

In order to develop effective conflict mitigation strategies, it is imperative to understand the fundamental causes of conflict and the motivation of the conflict actors. In our study, we find the major conflict causes to be asymmetric. On the Turkana side, drought related hunger, poverty and lack of pasture are the central conflict stimuli, while on the Pokot side the accumulation of wealth, payment of dowry and the expansion of territory are the main motives behind raiding (Table 8.2). This finding corroborates those of a study by Eaton (2010) which indicated that raided livestock is often not kept but predominantly sold to traders. Indications for this tendency were found in interviews with elders, and government officials. The key informant interviews revealed that three decades ago, the Turkana and Pokot pastoralists organized raids in large groups of 50 to 100 men ("mass raids"), but today they raid in groups of three to ten and can conduct five to eight raids at ago in different areas. Other mentioned causes of conflicts include proliferation of automatic firearms, political incitements, and disputes over territorial boundaries and control of key resources.

These findings are consistent with those of Mwaniki et al. (2007), Mkutu (2007) and Kumssa et al. (2009) who reported similar causes of violent conflicts among northeastern Kenya and southern Ethiopia pastoralists. It is, therefore, evident as presented in Table 8.2 and Figure 8.3 that violent conflicts in pastoral areas result from a number of factors that jointly limit availability of, deplete and reduce access to natural resource base. These factors are related to changes in the pastoral ecosystem that are directly or indirectly linked to natural resource, resource users and the larger geo-political system that undermine pastoralists' capacity to adapt to social, political and environmental shocks (Bevan 2007).

8.4.3 Pastoral Conflict Mitigation Strategies

Cattle raids have been reported by many (Moru 2010, Omolo 2010, Schilling et al. 2011) to be among the main causes of violent pastoral conflicts in northwestern Kenya. Traditionally, raiding related conflicts were resolved through mediations steered by council of elders (Edossa et al. 2005). Following a raid, the aggrieved community through their council of elders would initiate consultation with the elders from the raiders' community to negotiate for compensations and punishments of the culprits in a non violent manner. The recurrent and prolonged violence between the Pokot and Turkana partly points to the weakened customary conflict resolution institutions and overall decline of the influence of the elders on the youth's activities. The role of the elders in conflict mitigation has been further undermined by the Government's attempts to take over conflict resolution in pastoral areas (Knighton 2003, Mieth 2006, Schilling and Remling 2011). At county level, the state security system is coordinated by the district commissioner who relies on the information from the local chiefs to take action on already executed or intended raids.

This however, becomes cumbersome when raiding occurs across different administrative boundaries, as information has to be relayed back and forth over a long command chain. Due to poor roads and communication infrastructure as well as underequipped security personnel, the Government system may only prevent the traditional mass raids, which require a longer period to organize and are therefore, easier to detect as opposed to the contemporary raids.

According to the TUPADO (2011) conflict register, the Government took action in 13.4% of the raids reported between 2006 and 2009 and recovered 8.2% of the stolen animals. Not surprisingly, the majority of both the Pokot and Turkana expressed disappointment and distrust towards the Government's conflict mitigation efforts. The pastoralists, elders and women from both communities expressed similar views indicating the need to change focus from disarmaments to address the root cause of conflicts in an integrated approach. As an alternative to the state's reactive response to pastoral conflicts, participatory rangeland use planning that is consistent with the principles of traditional resource and conflict management systems, has the potential to mitigate drought-induced resource based conflicts. According to Berger (2003), resource-based conflict mitigation begins with the premise that access, ownership and management of resources are intricately linked and therefore conflict resolution cannot be addressed in isolation from resource use and management. During the past two decades, the concept of land use planning emerged to be one of the most suitable and innovative tools for sustainable utilization of limited resources in the rangelands (Morton 2001). Land use planning has also become an avenue for successful negotiations over tenure, access and resources stewardship rights to avoid potential conflicts among pastoralists.

At the core of the proposed interventions are the recognition and strengthening of traditional institutions and involvement of all stakeholders in conflict resolution. However, the already weakened customary institutions, inappropriate government approaches to conflict resolution and extreme climatic events, present a significant challenge to the realization of the desired results. As observed by Brown et al. (2007), the adaptive capacity of pastoralist communities currently seem not to be sufficiently robust to respond to the otherwise ordinary stressors and, therefore, extreme climatic variability can only exacerbate the situation. Weakened resource governance institutions work in concert with insecurity, reduced mobility, diminishing resource base and a myriad of socio-political factors. Together, these undermine pastoral risk management strategies and resilience to changing climatic and environmental conditions. One of the primary manifestations of this is large scale losses of livestock and famine that make pastoralists chronically dependent on food aid and susceptible to various stressors, among them, violent conflicts.

8.5 Conclusions

This study shows that competition for scarce natural resources aggravated by frequent droughts is central to the violent conflicts witnessed in the study area. The persistence of conflicts in northwestern Kenya is an indication of weak local institutions, disregard of traditional role of communities' participation in resolving resource-based conflicts, ill-informed interventions that address the symptoms instead of the root cause of the problem, and inadequate policies to address complex tenure issues in pastoral areas. Therefore, development of integrated policies and institutions rooted in traditional practices for managing natural resources and intercommunity conflicts is central to finding lasting solutions for recurrent unrest in the study area. Communities' participation in the elaboration and formulation of pastoral policies and implementation of resource and conflict management interventions is crucial for uptake and sustainability. However, any conflict resolution intervention must be cognizant of other equally important factors that work in combination with drought to cause resource scarcity thereby triggering competition and violent conflicts. Chief of these conflict catalysts are weak local institutions, poverty, proliferation of small firearms, political incitements, unclear property right regimes and commercialized cattle raiding.

Several recommendations key to achieving sustainable conflict-free resource sharing among pastoral communities arise from this study: Integration of customary and statutory institutions of governance by recognizing and supporting enforcement of the customary regulations; Enhancement of the presence and capacity of the state and community security and justice systems; Ensuring that all conflict resolution interventions in pastoral areas are planned and conducted in a manner that is sensitive to local values and priorities; and Application of conflict-sensitive approaches to pastoral development. The authors conclude that diminishing natural resource base does not automatically lead to violent conflict if there are functional local institutions, enforceable and respected land use plans, and mechanisms for negotiating cross-territorial grazing access in periods of scarcity. Participatory land use planning complemented with reciprocal grazing arrangements, therefore, provides the basis for achieving sustainable peaceful resource sharing among pastoral communities not only in northwestern Kenya but also in other areas which bear similarities with the region.

9. Synthesis

First, this chapter summarizes the key findings of the previous chapters to answer the research questions associated with the overall objective of this thesis (9.1). Second, overarching conclusions are drawn to inform further research and to provide policy recommendations (9.2).

9.1 Summary

As the earth continues to warm, it becomes increasingly important to understand the impacts of climate change on human livelihoods. The overall objective of this thesis was therefore to analyze the complex relations between climate change, vulnerability, adaptation and violent conflict.

The research into climate change and conflict is still in an early stage but some key points can already be made. Even in highly vulnerable regions climate change does not automatically lead to violent conflict. Only when other factors such as actors with the motivation and capability to forcefully purse their aims, weak institutions, marginalization and unequal resource access are at play, climate change becomes more likely to contribute to violent conflict.

Several long-term historical studies have found a coincidence of climate variability and armed conflict. Yet, in the analyzed periods such as 1500–1800, degradation of resources is more associated with cooler periods than with warmer phases. Temperature increases in recent periods are found to be significant in a few studies on violent conflicts in Africa but the overall evidence is not robust (Chapter 2). A major challenge for quantitative studies is the lack of adequate data on climate and particularly on conflicts. The most widely used conflict datasets of UCDP-PRIO for instance requires the involvement of the government for a conflict to be documented. Consequently, all non state conflicts are excluded which poses a major limitation considering that current research suggests a stronger linkage between climate change and intergroup conflicts on local scales (Chapter 2).

Generally, quantitative studies are suited to identify significant correlations between climate variables and conflict but they have limited explanatory power with respect to the causal pathways and their dynamics. Qualitative studies on the other hand are able to disentangle the complex conflict factors while these studies have difficulties to support their claims beyond case-specific conditions (Chapter 2).

Among the major research questions identified in Chapter 2, the following two are of particular significance. How does climate change affect the availability of resources and how do affected communities respond to an altered resource base?

To address these questions Chapter 3 presented a toolbox with instrumental theories, concepts and models. Complex climate-security interactions can be understood by conceptualizing them in factor-actor frameworks (see Figure 3.13, 5.1, and 9.1). These frameworks can serve as a basis for game theory and agent-based modeling as the example of the Nile river basin has demonstrated. The model suggests that the states of the Nile river basin can satisfy their water requirements most cost efficiently if they cooperate.

Chapter 4 showed that North Africa is highly vulnerable to climate change. But the reasons for the vulnerability differ from state to state. While in Libya and Algeria water scarcity is highest, Egypt faces the strongest population growth and in Morocco and Tunisia low per capita income is critical. Strong dependence on rain fed agriculture (except in Egypt) and high levels of corruption are general challenges for a region which is likely to experience a significantly warmer and drier climate in the future.

Despite the political and social changes since 2011, most prone to climate change related social instabilities are Algeria, Egypt and Morocco. In Morocco the cropping of marginal lands, depletion of groundwater resources and crop changes are likely to increase the vulnerability of the agricultural sector and particularly the poorer producers.

Several options of adaptation exist in Morocco. Generally, a shift in agricultural production from maximization to stabilization of output is recommendable. Commercialization of pastoral livestock husbandry is an option if it is based on traditional management institutions. Technical innovations such as replacement of firewood by solar energy could help to compensate climate related impacts (Chapter 4).

In Mali (Chapter 5) climate change could further decrease water resources and hence contribute to farmers moving into grazing areas and to herders entering farming land. However Chapter 5 and the recent violent confrontations between Tuareg rebels and Malian soldiers (see e.g. Guardian 2012) also indicate that political marginalization is a stronger driver of conflicts in Mali than climate change.

In northwestern Kenya (Chapter 6 through 8) climatic conditions play a role in the conflicts between the pastoral Turkana and Pokot. Based on analysis of conflict, climate, interview and literature records, the “Resource Abundance and Scarcity Threshold” (RAST) hypothesis was developed. The RAST hypothesis suggests that droughts increase the general pressure to use raiding as a means to compensate losses. The raiding is then conducted mostly during the rainy seasons to take advantage of the more fortunate raiding conditions (healthier animals, more cover, own herds need less attention). However, when rains partly or completely fail and a certain threshold of resource scarcity is reached, raids are conducted despite less fortunate raiding conditions. The majority of interviewees have stated that the raiding during droughts is not only to acquire desperately needed livestock but also to gain or secure control over scarce pasture and water resources (Chapter 6).

Climate projections for Kenya suggest that not only the temperature will increase but also the annual rainfall amounts and the intra and inter annual rainfall variability. On the one hand this offers the opportunity to improve the water endowment if catchment tanks are utilized. On the other hand the increased rainfall variability decreases the predictability and reliability of water and pasture resources. Floods and droughts become more likely (Chapter 6).

Drought and hunger in turn were the strongest motives for raiding on the Turkana side while accumulation of wealth, payment of dowry and the expansion of territory are central motives on the Pokot side. These motives are related to other conflict drivers which include political, social and economic marginalization as well as commercialization of raiding and the availability of small arms (Chapter 7).

Figure 9.1 summarizes some key findings of Chapter 6 through 8. Besides the already discussed link between climate change and conflicts (Chapter 6), the figure shows that the conflicts have significant direct and indirect effects on the wellbeing of the pastoral communities. Among the most direct effects of the raiding are loss of human lives, livestock, water, pasture and homes. The insecurity in the communities has led to ineffective resource use and closing of markets and schools (Chapter 7).

Different actors have a variety of instruments to strengthen the adaptive capacity of pastoral communities and to mitigate conflicts (Figure 9.1). However the instruments need to be applied carefully and conflict sensitive to avoid potential negative effects (Chapter 6 and 8). Instruments which address the specific raiding motives of each group are promising. In Turkana this would imply strengthening of the community’s capacity to ensure food security while in Pokot commercialization of raiding needs to be addressed. Pastoral livelihoods in both communities could be improved by ensuring safe and free pastoral movement across inner and inter state borders (Chapter 7). Further, local institutions, particularly chiefs and the council of elders need to be strengthened to promote inter communal resource sharing and conflict resolution (Chapter 8).

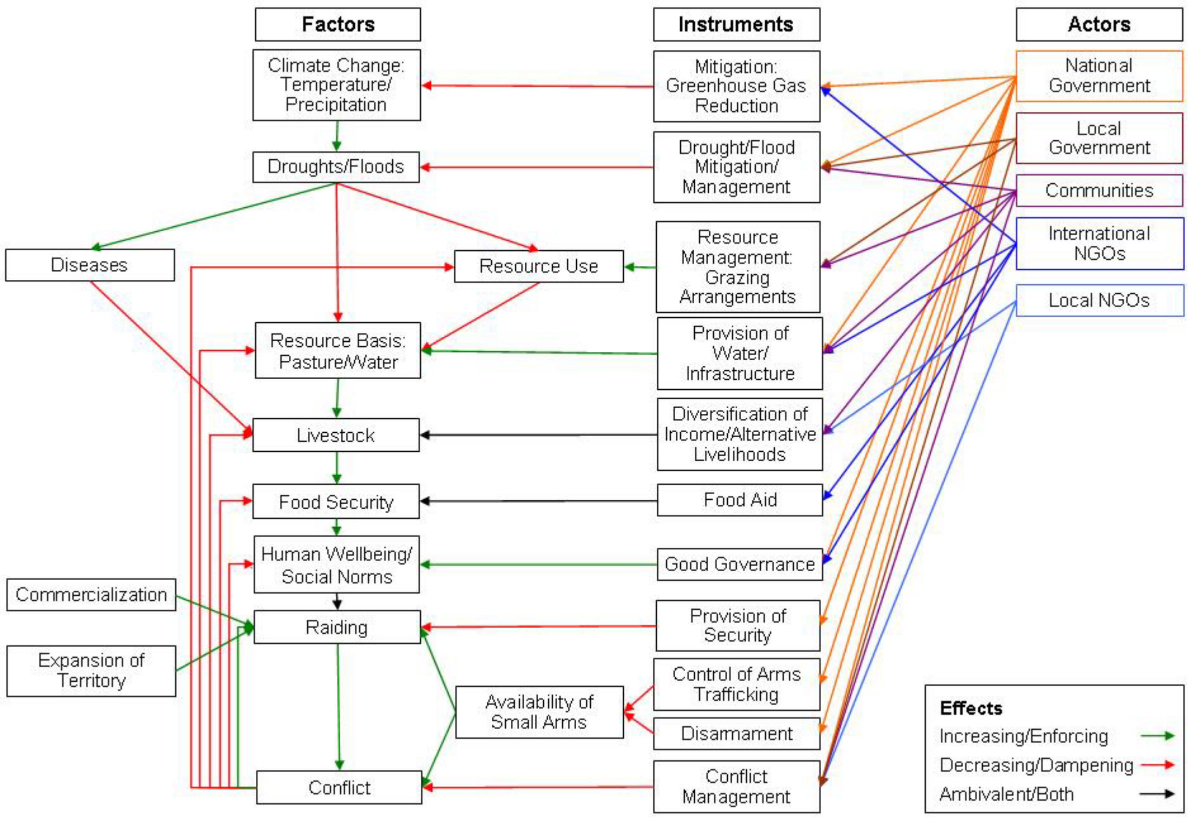


Figure 9.1 Schematic overview of factors, mitigation instruments and actors in the conflict between the Turkana and the Pokot (the author). A green arrow should be read as "if this factor increases, the dependant factor also increases". A red arrow should be read as "if this factor increases, the dependant factor decreases". The colors of the arrows on the right are to distinguish the different actors from each other.

9.2 Conclusions

Several overarching conclusions can be drawn from the summary. First, the complex relations between climate change and conflict can only be understood if questions of vulnerability and adaptation are answered. Consequently, any attempts to mitigate the effects of climate change on conflict need to address the specific vulnerability of each individual conflict case.

Second, this thesis has demonstrated that it is possible to grasp the complexity of the research matter by applying a multitude of methods at different geographic scales and across disciplinary and cultural boundaries. Particularly with respect to future research on the climate change and conflict nexus it is promising, as done in this thesis, to combine in-dept qualitative field research with quantitative data analysis and modeling approaches.

This points to third, the increased need of geo-referenced spatiotemporal databases which capture local, non state conflict dynamics. As more databases become available it will be possible to test hypothesis on the relation of climate change and conflict, like the one developed here, in other conflict contexts.

Fourth, policy recommendations can be given at the international and national level. The international community needs to limit the emissions of greenhouse gases to minimize the potential of climate change to act as a multiplier for security risks. Further, it is promising to increase the support of effective and conflict sensitive climate change adaptation in developing countries. It is challenging to give universal recommendations to national governments, as each pastoral context is different. For instance, while in Morocco a commercialized version of pastoralism is a feasible option to strengthen the production system, in northwestern Kenya a stronger integration of pastoralism into the market economy would likely contribute to more livestock raiding. Still, the following recommendations can be considered “no-regret” measures: acknowledging pastoralism as a productive and well-suited livelihood for arid and semi arid lands, respecting and integrating traditional institutions into policies, and ensuring safe and free pastoral mobility.

Failure to implement these measures bears the risk that climate change contributes to violent conflicts, not only in Mali and Kenya, but in arid and semi arid lands across the globe.

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Appendices

Appendix A Characteristics of key databases on indicators of conflict, societal stability, and disasters (the authors). Geo-referencing uses WGS84 (World Geodetic System Datum 84)

Database	Provider	Scale	Resolution	Key variables	Source
Conflict databases					
UCDP/PRIO Armed Conflict Dataset	Uppsala Conflict Data Program	global	country level, annual, 1946-2010	number of conflict-years; conflict year is one with at least 25 battle-related deaths.	http://www.pcr.uu.se/research/ucdp/datasets/ucdp_prio_armed_conflict_dataset/
UCDP Georeferenced Event Dataset	Uppsala Conflict Data Program	Africa	point resolution of the event, annual, 1989-2010	geo references, state-based, non-state and one-sided violence leading to at least one death	http://www.pcr.uu.se/research/ucdp/datasets/ucdp_ged/
UCDP Non-State Conflict Dataset	Uppsala Conflict Data Program	global	country level, annual, 1989-2010	conflicts of non-state-actors, three organizational levels distinguished, estimates of deaths	http://www.pcr.uu.se/research/ucdp/datasets/ucdp_non-state_conflict_dataset_/
UCDP One-sided Violence Dataset	Uppsala Conflict Data Program	global	country level, annual, 1989-2010	violence of a government or organized group against civilians with at least 25 deaths, estimates of deaths	http://www.pcr.uu.se/research/ucdp/datasets/ucdp_one-sided_violence_dataset/
UCDP Battle-Related Deaths Dataset	Uppsala Conflict Data Program	global	country level, annual, 1989-2010	number of deaths in armed conflicts that have totaled at least 25 casualties	http://www.pcr.uu.se/research/ucdp/datasets/ucdp_battle-related_deaths_dataset/
Correlates of War Non state War Dataset	Correlates of War Project	global	country level, one record per conflict, 1816-2007	parties involved in conflict, start and end of conflict, initiator, result, number of fatalities	http://www.correlatesofwar.org/
Correlates of War Intra-State War Dataset	Correlates of War Project	global	country level, one record per conflict party, 1816-2007	parties involved in conflict, start and end of conflict, initiator, result, number of fatalities	http://www.correlatesofwar.org/
Correlates of War Inter State War Dataset	Correlates of War Project	global	country level, one record per conflict party, 1816-2007	parties involved in conflict, start and end of conflict, initiator, result, number of fatalities	http://www.correlatesofwar.org/
Correlates of War Extra-State War Dataset	Correlates of War Project	global	country level, one record per conflict party, 1816-2007	parties involved in conflict, start and end of conflict, initiator, result, number of fatalities	http://www.correlatesofwar.org/
KOSIMO Database/	Heidelberger Institut für	global	country level, one record per conflict,	parties involved in conflict, start and end of conflict, issues at stake,	http://hiik.de/de/kosimo/index.html

Conflict Information System	Internationale Konfliktforschung		1942-1998	location, resolution, result of conflict, estimate of casualties	
Armed Conflict Location and Event Data (ACLED)	Centre for the Study of Civil War, International Peace Research Institute, Oslo	Africa, Balkan, other countrie s	point resolution of the event, annual, 1997-2010	geo references, parties involved in conflict, start and end of conflict, location, estimate of fatalities	http://www.acleddata.com/
Inventory of Conflict and Environment	American University of Washington	more than 200 indivi-dual case studies	varying spatial and temporal resolution, depending on case study	location, habitat affected, detailed description of conflict background, actors, environmental setting, type of conflict, fatalities, link between conflict and the environment	http://www1.american.edu/TED/ice/ice.ht m
International Crisis Behavior Project	Center for Int’l Development and Conflict Management, University of Maryland	global	country level, one record per conflict or conflict party, 1918-2007	crisis dimensions, duration of conflict, intensity, conflict parties involved, location, result, categorization of conflict, mediation of the crisis	http://www.cidcm.umd.edu/icb/
Event Data Project on Conflict and Security	Freie Universität Berlin	Sub-Sahara n Africa	point resolution of the event, annual, 1990-2007	geo references, date, location, actors, fatalities, event type (one-sided violence, fighting, suicidal bombings, landmines, conventional weapon attacks)	http://www.sfb-governance.de/teilprojekte/projekte_pha se_1/projektbereich_c/c4/The_EDACS/i ndex.html
International Military Intervention Dataset	Kansas State University	global	one record per conflict, daily, 1946-2005	parties involved in conflict, start and end of conflict, type of conflict, casualties	http://www.k-state.edu/polsci/intervention/
Small Arms Trade Database	Norwegian Initiative on Small Arms Transfers	global	searchable database, country to country, annual, 1962-2010	transfers of small arms between countries, number of weapons, estimated value, licenses	http://www.prio.no/NISAT/Small-Arms-Trade-Database/
Social Conflict in Africa Database	Robert S. Strauss Center for International Security and Law	Africa	country level, one record per conflict, daily, 1990-2010	parties involved in conflict, type and issue of conflict, location, start and end of conflict	http://ccaps.strausscenter.org/scad/confli cts

Behavioral correlates of war	R.J. Leng, Middlebury College	selected countries	country level, 40 selected crises between 1816 and 1979	parties involved in conflict, start and end of conflict, location, estimate of fatalities	http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/8606
Conflict and Mediations Event Observations	The Kansas Event Data System	Balkan, Levant, West Africa	daily, 1979 or 1989-2002	detailed description of the mediation of conflicts	http://web.ku.edu/~keds/data.html
Transboundary Freshwater Dispute Database	Oregon State University	six databases	watershed level, varying temporal extent	geo references (in part), emphasis on conflict resolution processes, international water relations, treaties. Spatially referenced biophysical, socioeconomic and geopolitical data	http://ocid.nacse.org/tfdd/
Societal Stability Databases					
Social, Political and Economic Event Database	Cline Center for Democracy, University of Illinois	global	point resolution of the event, one record per incidence, daily, 1946-2011	geo references, type and intensity of the event, location and date, how and why of event, targets/victims, fatalities	http://www.clinecenter.illinois.edu/research/speed.html
Geographic Distribution of Climate Change Vulnerability	Socioeconomic Data and Applications Center, Columbia University	global	country level, two points in time, projections for 2050 and 2100	vulnerability of countries to climate change by means of an index based on human resources, economic capacity and environmental capacity, infrastructure, food security, ecosystems, human health and water resource	http://sedac.ciesin.columbia.edu/mva/ccv/index.html
Polity IV Political Regime Characteristics and Transitions Database	Center for Systemic Peace	global	country level, annual, 1800-2010	indices of democracy and autocracy, indicators for the characterization of state authority, transitions between different polity regimes	http://www.systemicpeace.org/polity/polity4.htm
Political Rights Index	Freedom House	global	country level, annual, 1972-2008	index of political freedom	http://www.freedomhouse.org/
Political Terror Scale	www.politicalterrorscale.org	global	country level, annual, 1976-2010	index of human security based on annual reports by amnesty international and the U.S. State Department	http://www.politicalterrorscale.org/

Failed State Index	The Fund for Peace	global	country level, annual, 2005-2011	index of state functioning that is based on a composite score from twelve social, economic and political and military indicators	http://www.fundforpeace.org/global/?q=fsi
Global Peace Index	Institute for Economics and Peace	global	country level, annual, 2007-2011	index of peacefulness in countries based on 23 qualitative and quantitative indicators	http://www.visionofhumanity.org/info-center/global-peace-index-2011/
Alliance Treaty Obligations and Provisions	Rice University	global	country level, daily, 1815-2003	treaties between countries, start and end dates, member countries, contents, effectiveness	http://atop.rice.edu/data
Minorities at Risk	Center for International Development and Conflict Management, University of Maryland	global	country level, one record per minority group, annual, 1980-2006	demographic characteristics of minority groups, conflicts, 71 indicators total	http://www.cidcm.umd.edu/mar/data.asp
Disaster Databases					
EM-DAT International Disaster Database	Centre for Research on the Epidemiology of Disasters	global	searchable database, country level, annual, 1900-2011	search by geographic location, time period and disaster category: number of disasters, fatalities, affected, economic damages	http://www.emdat.be/
Risk Indicator Databases					
Global Climate Risk Index	Germanwatch	global	country level, annual, 1991-2010	index based on data of impacts of extreme weather events and corresponding socio-economic indicators	http://www.germanwatch.org/klima/cri.htm
Data collections					
Paul Hensel's General International Data Page	University of North Texas			overview of databases on states and the international system, state capabilities, alliances, and various geographic and social science indicators	http://www.paulhensel.org/dataintl.html

Appendix B Main findings and statements on the empirical links between environmental and conflict variables since 2000 (the authors). Page numbers are given in brackets. The column "Link" denotes whether there is a clear relationship between the variables (y) or not (n) or whether the study finds that the relationship is ambivalent (a)

Main findings / statements Link Reference	Link	Reference
"Climatic factors do influence the risk of conflict incidence [in Kenya], wetter years are less safe than drier ones." (25)	y	Theisen (2010)
"Our results do not show a clear-cut picture: We present some evidence that periods with lower temperatures in the pre-industrial era are accompanied by violent conflicts [in Europe]." (77)	a	Tol/Wagner (2010)
"In great contrast to popular conceptions ... the empirical foundation for a general relationship between resource scarcity and armed conflict is indicative, at best; and numerous questions remain to be answered regarding the exact nature of the proposed causal association between climate change and conflict." (93)	a	Buhaug et al. (2010)
"climate variability is a poor predictor of armed conflict. Instead, African civil wars can be explained by generic structural and contextual conditions: prevalent ethno-political exclusion, poor national economy, and the collapse of the Cold War system." (16477)	n	Buhaug (2010)
"There are three times more killings during rainy season than during the dry seasons. This indicates that in northern Kenya raids-related violence is influenced by climatic fluctuations, which also implies that climate change will have an effect on (in)security." (536)	y	Witsenburg/Adano (2009)
"Climate change is one of a range of factors causing natural resource scarcity; while natural resource scarcity is one of a range of factors causing conflict [in Kenya]." (6)	y	Campbell et al. (2009)
"We find strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war. When combined with climate model projections of future temperature trends, this historical response to temperature suggests a roughly 54% increase in armed conflict incidence by 2030, or an additional 393,000 battle deaths if future wars are as deadly as recent wars." (20670)	y	Burke et al. (2009)
"The data-driven modeling of behavior has shown that environmental resources can result in disproportionately large variations in the frequency of conflict and cooperation [in Kenya]." (7)	y	Kennedy et al. (2008)
"In the North East Nigeria, like most parts of the northern axis of the country, environmental scarcity occasioned by lowering amount of rainfall has caused tremendous damage to human life through incessant conflict in the quest for scramble and domination of scarce existing land resources." (322)	y	Obioha (2008)
"The effect of climate change on armed conflict is contingent on a number of political and social variables, which, if ignored by analysts, can lead to poor predictions about when and where conflict is likely." (315)	a	Salehyan (2008)
"We ... roundly conclude that large scale community relocation due to either chronic or sudden onset hazards is and continues to be an unlikely response." (iv)	n	Raleigh et al. (2008)
"disasters are thought to exacerbate conflict risk primarily through reduction in the supply of livelihood resources, economic loss, and weakened government institutions, particularly in societies with pre-existing tensions … Moreover, disasters attract lootable aid (food, transport equipment, etc.) and facilitate rebel recruitment through increasing numbers of orphans." (19/20)	a	Buhaug et al. (2008)
"A high level of land degradation is the only factor that significantly increases the risk of civil conflict, although this result should be interpreted with caution. The general conclusion of this study is that scarcity of natural resources has limited explanatory power in terms of civil violence, whereas poverty and dysfunctional institutions are robustly related to conflict." (801)	n	Theisen (2008)

"It appears from this disaggregated analysis that demographic and environmental variables only have a very moderate effect on the risk of civil conflict". (689)	n	Raleigh/Urdal (2007)
“Climates more suitable for Eurasian agriculture are associated with a decreased likelihood of conflict, while freshwater resources per capita are positively associated with the likelihood of conflict.”(695) “… interannual variability in rainfall is a more significant determinant of conflict than our measures of climate, land degradation, and freshwater resources.” (710)	a	Hendrix/Glaser (2007)
“This paper has argued that climate change undermines human security in the present day, and will increasingly do so in the future.” (651)	y	Barnett/Adger (2007)
“Results show that warfare frequency in eastern China (its southern portion in particular) significantly correlated with the Northern Hemisphere temperature oscillations. Almost all peaks of warfare frequency and dynastic changes occurred in cooling phases.” (403)	y	Zhang et al. (2007b)
“While it is possible that climate change may lead to more conflict in the future, it has not so far caused a reversal of the current trend towards a more peaceful world.” (635)	a	Nordås/Gleditsch (2007)
“Environmental migration crosses international borders at times, and plays a role in conflict. Environmental migration does not always lead to conflict, but when it does, the conflict intensity can be very high, including interstate and intrastate wars.” (668)	y	Reuveny (2007)
“... the extent to which climate change triggers 'a succession of new wars' in Africa ... depends more on governance and governments than on the strength of the climate 'signal' itself. This being so, using projections of climate change in isolation from other factors is probably a poor way to predict future conflict.” (1153)	n	Brown et al. (2007)
“…higher levels of accumulated consumption of renewable resources (the so-called ecological footprint) is associated with a lowered risk of civil conflict.” (345)	y	Binningsbø et al. (2007)
“A shared basin is positively and significantly related to conflict, while a river boundary is not. Support for the scarcity view of conflict is somewhat ambiguous. … wealthier countries canafford to compensate for scarcities by technological substitution or innovation …. The analysis… suggests the existence of an environmental Kuznets curve – shared river basins increase the risk of conflict more for middle-income countries than for low-income countries.” (378/379)	a	Gleditsch et al. (2006)
“sharing a river basin appears to have at least some positive impact on overall cooperation in a dyad, but …several other factors such as scarcity, region, and regime type affect this relationship.” (1)	a	Brochmann/ Gleditsch (2006)
“Countries experiencing high rates of population growth, high rates of urbanization, or large refugee populations do not face greater risks of internal armed conflict. There is some indication that scarcity of potential cropland may have a pacifying effect. However, where land scarcity combines with high rates of population growth, the risk of armed conflict increases somewhat.”(417)	a	Urdal (2005)
“Using rainfall shocks as instrumental variables for economic growth, we find that growth shocks have a dramatic causal impact on the likelihood of civil war: a five-percentage-point negative growth shock increases the likelihood of a civil war the following year by nearly one-half.” (746)	y	Miguel et al. (2004)
“Per capita wealth is significantly negatively associated with conflict. The size of the population and population density are positively associated with conflict.” (397) “…densely populated rural societies with access to greater per capita renewable resource wealth tend to have more conflict, a result that is highly significant statistically.” (410)	y	de Soysa (2002b)

Appendix C Guideline for interviews with pastoralists (both Turkana and Pokot)

General changes

- What changes have you noticed in general over the past 10 to 20 years?
- What changes have you noticed in the community?

Climatic conditions / water availability

- Have you noticed any changes in the weather?
- Does it rain less or more?
- When does it rain less/more?
- Have the long or short rains changed? How?
- Are the long rains shorter or longer?
- Are the short rains shorter or longer compared to 2o years ago?
- How reliable are the rains?
- Has the water availability changed?
- Has it gotten warmer/cooler?

Herding

- Has your herd movement changed? How has it changed?
- Where do you drive your herd? Within Turkana? To Uganda? To Ethiopia? To Sudan?
- How many animals does your herd have?
- What kind of animals do you have?
- How has the size of your herd changed? Has it increased/decreased?

Adaptation

- What do you do when there is less or no rain?
- What else do you try besides driving your herd to other places?

Security situation

- Do you feel secure in your community?
- Has the security situation in your community changed? How has it changed?
- Do you feel as secure as five, ten or twenty years ago?
- Are there areas where you feel insecure? Where are these areas?
- Are there situations that you try to avoid?
- Do you carry a gun when you are with your herds?

Raiding

- Are you aware of any raiding activities?
- Have you noticed any changes in the raiding activities over the past 10 years? What has changed?
- Have raids become more or less violent?
- Has the number of raids increased?
- Who is raiding whom? Around what age are the raiders?
- What is the raiding about? / Why do people raid?
- What other factors influence the raids?
- When do people raid? During rainy season? During drought?
- Where are the raids taking place?
- How do the raids affect your community?
- How do the raids affect the relationship among communities who are involved in raiding?

Resolution of conflict and raiding

- What would help to decrease the raiding?
- What would help to improve the relationship among communities who are involved in raiding?
- Are peace meetings (“barassas”) useful?

Government

- Is the government involved in the conflict between the communities? How?
- What do you expect from the government?
- What should be the first thing the government should do or stop doing?

Appendix D Impressions from the field research in northwestern Kenya

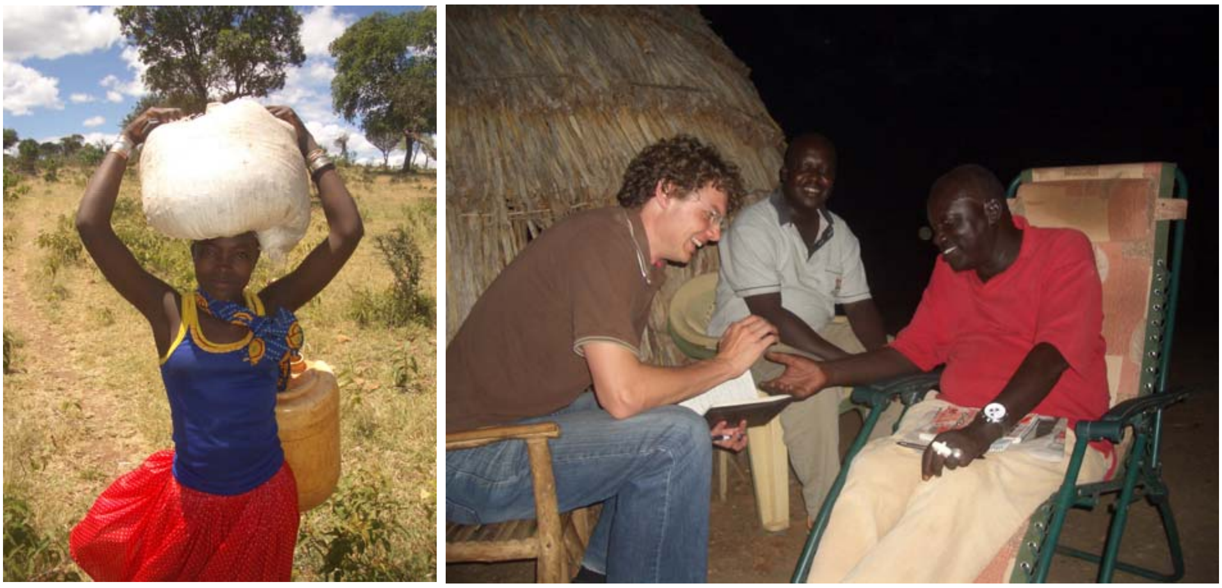

Livestock at a watering point near Alale, Pokot North (left) and distribution of relief food in Lokiriama, Turkana (right)


Interview in Lokiriama (left) and in a river bed near Alale (right)


Interview with youth in Alale (left) and a youth meeting in Lokiriama (right)

Focus group discussion in Lokiriama (left) and Lasak, Pokot North (right)

On the road in northwestern Kenya



Woman near Alale (left) and interview with Chief Lokuruka and Raphael Locham (in the back)

Acknowledgements

Several people have contributed directly or indirectly to this thesis.

First of all, I thank the members of my PhD panel who offered a great forum to discuss, reflect and evaluate my research and its progress. I thank Jürgen Scheffran for being a very good first advisor who has challenged and supported me but also gave me enough room to develop own ideas. Similar commendations can be given to my second advisor Jürgen Oßenbrügge who has not only supported me throughout my PhD period but also encouraged me to pursue a PhD in the first place. Angela Oels has been a great panel chair who brought controversial perspectives together to summarize them in a constructive matter. I also enjoyed our talks beyond scientific topics.

I thank all my colleagues at CLISEC for their manifold support. I thank Michael Link for being my roommate. I enjoyed reflecting ideas and fixing technical problems with him. Jasmin Kominek and Tobias Ide helped me to integrate sociological and political perspectives in my research. I am grateful to Kesheng Shu, Liang Yang, Grace Ngaruiya and Giovanna Gioli who have brought in different cultural dimensions and made CLISEC more lively. I thank the German Science Foundation (DFG) for funding the general research of CLISEC through the Cluster of Excellence "CliSAP" (EXC177).

I thank my fellow PhD candidates, particularly Christian Daneke and Thomas Langkamp for our scientific and non scientific discussions.

Without the co-authors of the publications this thesis would not have been possible in its current form. I thank all co-authors very much. With Korbinian Freier I spent working days and weekends debating pastoral adaptation in North Africa. With Francis Opiyo I had extensive discussions about pastoral conflicts in Kenya. From my pleasant exchange with Elke Hertig I was able to deepen my understanding of climate modelling. Thomas Weinzierl has been great in helping me to produce maps and analyze data.

As the PhD thesis entails significant administrative workload and financial costs, I thank Nadine Frömter and Nadine Heim from KlimaCampus and Andreas Schiller from the Institute of Geography for their support. Oliver Dilly and the whole SICSS (School of Integrated Climate System Sciences) team were always ready to assist in any questions related to the PhD process. I also thank SICSS, Anke Allner from

KlimaCampus and the German Academic Exchange Service (DAAD) for their financial support of the field research.

The field research would not have been possible in the conducted form, if it was not for one man. Raphael Locham not only helped me to find contacts, organize transport, security and a working space, he also became a close friend who took me into his home in Lodwar. Here, Christin Locham's "akimuj" (food) and playing with all watoto (children) helped me to recover from the research in the rural areas. In this context, I am grateful to Tony Epaya for assisting my research in Turkana with translations and organization of interviews and focus group discussions. We have experienced situations together that neither of us will probably forget so soon.

I thank Sam Owili and the whole Practical Action team in Lodwar for sharing a working desk with me, giving me rides and being so supportive. I especially enjoyed the time with Paul Ekutana who introduced me to technical solutions for water scarcity. I am thankful to Jackson Kiyonga of the National Drought Management Authority in Turkana for our discussions and the exchange of GIS layers and maps. Likewise I thank Sam Ekal and the team of TUPADO for their insights and the access to the conflict register. In Nakuru, I thank Michael Odhiambo for his support and for introducing me to the wonderful staff at Reconcile.

In the field, I very much thank chief Lukas Lokuruka Akeru and chief Simion Muya Echakan for accommodation, protection and assistance with the interviews. The time in Lokiriama and Lobei was highly interesting and definitely unforgettable.

The same is true for Pokot where I would like to thank Father Guduchi and his Parish in Alale for accommodation and for letting me use the facilities and vehicles. Without them I would not have been possible to reach all the remote villages. On these trips I was accompanied by my wonderful research assistant Theresa Marc who helped me in so many ways and taught me so much about the Pokot culture. I also thank Charles Rotich who was instrumental in interviewing the raiders and the youth. Peter Ngati and his library were great assets as well.

Across Kenya and particularly in Turkana and Pokot I thank all interviewees for being so open and cooperative. I thank Clemens Greiner in Baringo and Matthias Oesterle in Moroto for their support. In Nairobi, thanks go to Beth Njeri Njiru, Mirjam Tutzer, Yvonne Kunz, Moses Akuno and all my roommates of the Gitanga apartment for being good friends and supporting me in many ways.

Further I thank all people who I interacted with on conferences, summer schools and workshops for the exchange of ideas. In this regard I particularly thank Janani Vivekananda for her reflections.

I thank Bernice and Ken Van Sickel for their language editing and for being my American home.

Finally, I know that the PhD period and especially the field research asked a lot from my family, partner and closest friends. I am particularly thankful to my parents, my sister, Maike Hansen, Melik Sahin, Anna Stricker, Harald Kurtze and Cornelius Schildknecht for always being there for me.