Jürgen Scheffran
P. Michael Link
Janpeter Schilling

Theories and Models of the Climate Security Link

University of Hamburg
Research Group Climate Change and Security

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CLISEC-3

Theories and Models of the Climate-Security Link

Jürgen Scheffran, P. Michael Link, Janpeter Schilling
Research Group Climate Change and Security
KlimaCampus, Universität Hamburg
ZMAW, Bundesstrasse 53
20146 Hamburg, Germany
eMail: *juergen.scheffran@zmaw.de*

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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 of regional impacts of climate change is combined with a micro-level analysis of potential environmental conflicts, focusing on regional cases in the Mediterranean region and Northern Africa (Nile river and Egypt, land use in the Sahel region) that could turn into climate hot spots. 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.

Introduction

Global warming has significant potential implications for security and conflict. Several studies argue that climate change aggravates environmental degradation and resource scarcity, which may contribute to violent conflict in a number of ways (Campbell et al. 2007; CNA 2007; Maas/Tänzler 2009; WBGU 2008). This includes resource captures, mass migrations, and conflicts over the distribution of risks and costs of economic exploitation of resources. The causal chains from climate stress to human insecurity, societal instability and violent conflict are complex and shaped by many interactions that are not yet fully understood. While the research literature does not provide clear evidence of the environment-conflict hypothesis from previous cases (Barnett 2003; Barnett/Adger 2007; Nordås/Gleditsch 2007; Raleigh/Urdal 2007), the expected magnitude of climate change could severely undermine human security and overwhelm adaptive capacities of societies in many world regions, bearing a significant conflict potential. This has contributed to an increasing securitization of climate policy (Brauch 2009; Brown 2007; Brzoska 2009; Carius et al. 2008; Scheffran 2008a; Scheffran 2009).

Although the most serious climate risks and conflicts are expected in poor countries that are vulnerable to climate change and have less adaptive capacity, wealthy countries are not immune to such threats either. As climate change increases the inequality between the rich and the poor, pressure for large-scale migration could mount on a regional and global scale. In the worst-affected regions of the world, conflicts may spread to neighboring states, e.g. through refugee movements, ethnic links, environmental resource flows, or arms exports. Such spillover effects could destabilize entire regions and expand the geographical extent of a crisis, overstretching global and regional governance structures. The devastating impact of hurricane Katrina in 2005 and the 2003 heat wave in Europe demonstrated that not only poor countries are vulnerable to climate change but that the world's richest nations can be seriously affected by severe weather events as well. Developed countries cannot ignore the possible economic impacts and migratory pressures and may be drawn into climate-induced conflicts in regions that are particularly hit by the impacts. Furthermore, climate change can increase resource competition between major powers (e.g. in the Arctic) and induce geopolitical strategies involving additional risk and conflict potential (e.g. expansion of nuclear power, bioenergy, geo-engineering).

To avoid or manage these possible conflicts, a preventive climate policy could be applied aiming at strengthening institutions and cooperation between developing and developed countries to build a security community against the risks of climate change. The development of new cooperative approaches and institutional frameworks is a challenge for both regional and global governance structures that combines solutions from both climate and security policy to enhance climate security. Adaptive governance seeks to influence the many decision points along the causal chains from climate change to human insecurity, societal instability and violent conflict to avoid cascading risks and allow natural and social systems to adapt to the complex environment created by climate change. Agent-based approaches to governance, from the local to the global level, can be used to represent real-world agents who respond to changing circumstances and act according to specific decision rules on the basis of incomplete knowledge and updated information within a spatial and temporal window of perception. They are also appropriate to manage the multi-level decision-making process between local and global agents and the transition between individual and collective action that leads to the formation and breakup of societal structures. Such a framework simulating global and regional governance structures is adequate to analyze the conditions required for moving from conflict to cooperation.

This contribution provides a framework for an integrated assessment of climate impacts on human security, societal stability, and violent conflict in high-risk climate hot spots. The setup serves as a basis to assess the conditions for adaptation, conflict resolution, and cooperation. Advanced data analysis and computational modeling tools are integrated and combined with input from decision-makers and stakeholders in regional situation assessment. Then it is possible to develop science-based integrated strategies and solutions that help to reinforce societies facing climate change. A main point of this study is to identify conditions leading to conflict or cooperation, with a focus on case-studies in the larger Mediterranean region and Northern Africa.

Integrated assessment framework of climate-society interaction

Figure 1 shows the causal links between climate change, environmental stress, human needs, and societal consequences. Changes in the climate system, such as pronounced changes in temperature and precipitation, affect environmental systems and natural resources (e.g. soil, ecosystems, forests, biodiversity) through a sequence of complex interactions. Environmental changes can have adverse impacts on human needs and values, which provoke human responses that affect social systems. Depending on the degree of vulnerability, the socio-economic 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. Interdependencies between these factors may lead to social instability that can manifest itself in violent forms such as riots, insurgencies or urban violence, which in return can worsen social disruption. A feedback loop allows societies to adapt to the changing situation and mitigate climate stress through strategies and institutions that apply technology, human and social capital to adjust the economy and the energy system to the altered environmental conditions. To determine the couplings along the causal chain, it is important to identify the sensitivities that measure how variables in one system are influenced by changing variables in another. An example is the desertification caused by climate change, which undermines food security and forces people to migrate or respond violently. Many more of such linkages are feasible and further research will focus on identifying the most likely and most significant teleconnections. In a next step, the sign and magnitude of these relationships are estimated. Finally, they are presented in regional impact graphs, which serve as an analytical framework.

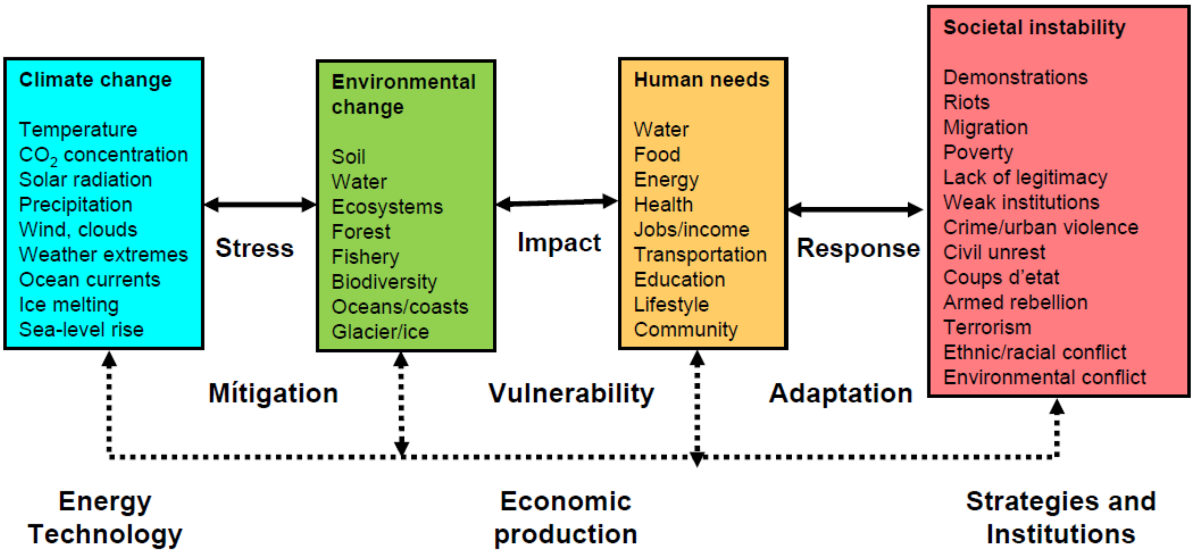

Figure 1: Causal relationships between climate change, environmental impacts, human needs, and societal impacts (Scheffran 2010).

The significance of the impact of climate change on society can be deduced from the links between the variables along the causal chain, i.e. how much the change of one variable x induces a change in another variable *y*, which is denoted as sensitivity y_x. According to the IPCC 2007 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 (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)." A prominent example is the so-called climate sensitivity, i.e. the temperature change induced by a doubling of CO_2 concentration in the atmosphere. Since several intermediate variables are involved, estimates are needed for each of the individual sensitivities, which in combination yield the overall sensitivity.[1]

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 2). Changes in the climate system (*C*) affect the natural environment and resources (*N*). Environmental changes will influence human needs and desires (*H*) and can ultimately trigger societal impacts and instability events (*S*). The links between the variables of each level can be represented by a sensitivity matrix (X_Y) which indicates how sensitive a variable in system *X* is with regard to a variable change in system *Y*.

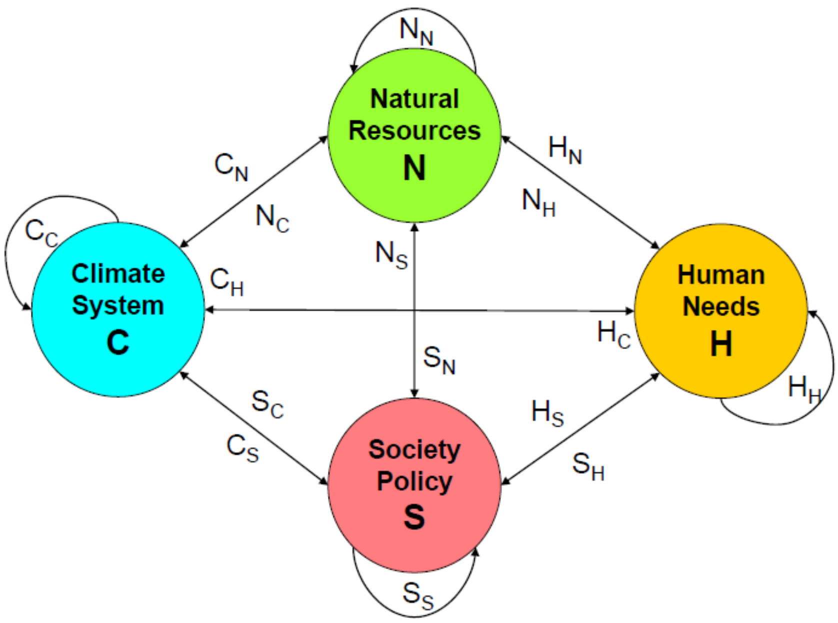

Figure 2: Sensitivities in the climate-society interaction (Scheffran 2010).

Statistical multivariate analysis of data on historic incidents of societal instability makes it possible to estimate the values of the sensitivity matrices such as the stress induced to natural resources by climate change (N_C), the impact of environmental change on human needs and living conditions (H_N), or the societal consequences of changes in human living conditions (S_H). The coupling between climate stress and societal instability (S_C) captures the direct connections from climate change to societal stability. In addition to the direct linkages, 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. A network of interconnections between the various system variables (Table 1) can be constructed using these sensitivities, which can be analyzed to understand the impacts of e.g. severe climate events on society. Relevant changes in the climate-environment interaction are denoted as events, e.g. an increase or a drop in precipitation, the loss of a species or a disaster. Stability analyses of the interaction matrix of network linkages can be performed on the basis of the sensitivities between the various system levels. With this setup it is possible to assess the

[1] The sensitivities determine how a change in one variable x affects either its own dynamics (self-impact x_x) or another variable *y* (mutual impact y_x). The self-impacts determine whether an increase in variable *x* leads to further growth ($x_x > 0$), which is the case for exponential growth, or to a decline ($x_x < 0$) for exponential decline. The mutual impacts either represent a positive coupling ($y_x > 0$) or a negative one ($y_x < 0$). For human action, the self impacts determine whether the action by one actor has a positive or negative effect on the same actor; the mutual impacts represent the impacts on other actors, which can represent friendly, hostile or neutral relations.

impacts of triggering events (e.g. mass migrations, extreme weather events, social movements), and find cascading sequences and tipping points. It is also possible to determine the probability of future destabilizing events occurring under specified conditions, which can be used to develop an early warning system.

Cause	**Effect**	**Sensitivity**	**Explanation (with estimated sign of sensitivity)**
climate change	climate change	C_C	Despite a dampening in the climate system (+), increased carbon emissions can trigger rapid climate change through positive feedbacks and the crossing of tipping points (-)
climate change	natural resources	N_C	Although in some areas biomass may grow better with higher carbon or temperature (+), climate change reduces the carrying capacity and productivity of many natural resources (-)
climate change	human values	H_C	Changing climate negatively affects human well-being and security, e.g. through disasters and adverse climatic conditions (-); in some cases benefits are possible (+)
climate change	society	S_C	Natural disasters and large-scale climate change can weaken societal structures (-)
natural resources	climate change	C_N	There are some feedback mechanisms from natural resources that aggravate climate change, e.g. loss of biomass releases more carbon (-).
natural resources	natural resources	N_N	For many natural resources there is a tendency towards exponential growth at low resource stocks (+) and for logistic dampening at high resource stocks (-)
natural resources	human values	H_N	Since human needs depend on natural resources, their decline leads to a loss of human values (+)
natural resources	society	S_N	Since various socio-economic structures depend on the exploitation of natural resources, their decline directly affects these structures (+)
human values	climate change	C_H	Threats to human needs may lead to more deforestation and use of fossil fuels (-) or to responses that reduce emissions, e.g. less production and consumption (+).
human values	natural resources	N_H	A loss in human values can lead to more exploitation of natural resources (+) or to less exploitation (-)
human values	human values	H_H	Depending on individual responses, a loss in human values can lead to a downward spiral (+) or to counteractions that improve the situation and compensate for the losses (-)
human values	society	S_H	Threats to human security can provoke human responses that undermine societal stability (+); effective strategies would stabilize society (-), e.g. through cooperation
society	climate change	C_S	More wealthy societies may either increase emissions (+) or reduce emissions (-)
society	natural resources	N_S	Societal degradation can lead to more exploitation of natural resources (+) as a compensation for loss or to less exploitation through sustainable development (-)
society	human values	H_S	More stable societies are better suited to satisfy human needs (+)
society	society	S_S	Within a stability range societies tend to stabilize themselves (-), outside of this range destabilizing tendencies may prevail (+)

Table 1: Typical sensitivities in the climate-society interaction

Estimates of the sensitivities can be based on qualitative considerations (Table 1 and Figure 3), However, many of the sensitivities are unknown in quantity and depend on other variables. Due to non-linear effects, an increase in average mean temperature above a certain threshold (such as 2°C) may result in disproportionate impacts, such as a widespread reduction of agricultural output in regions 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 force parts of the population to migrate into neighboring countries. It is important how levels of security and risks of potential conflicts are affected by rising temperatures in a particular region and how anthropogenic and societal response patterns influence that development.

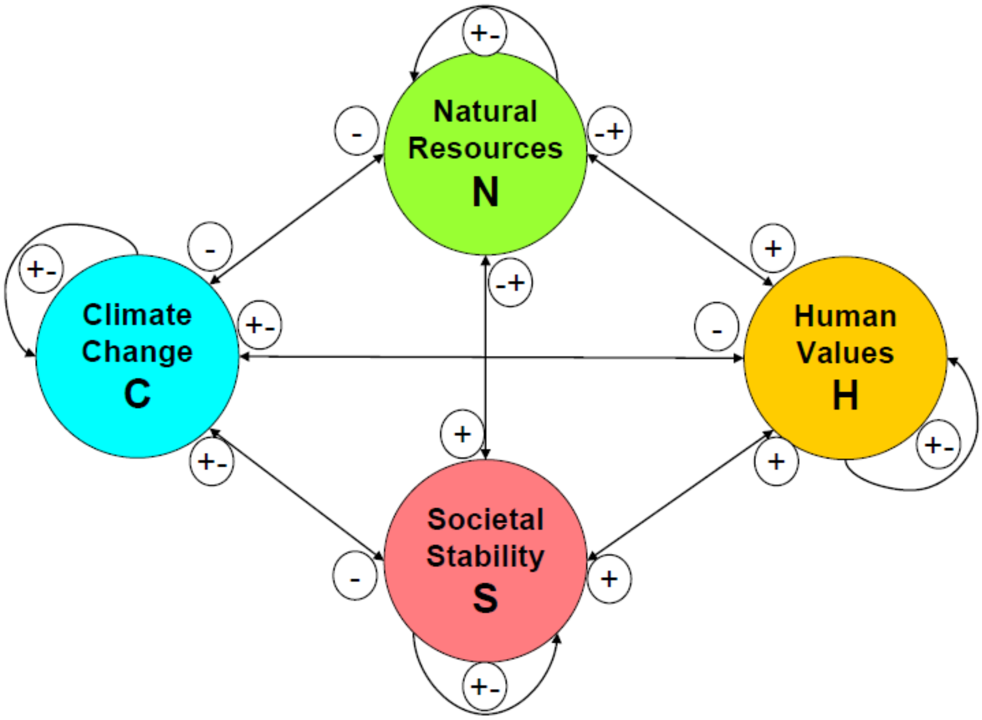

Figure 3: Typical signs of sensitivities in the climate-environment-human-society interaction.

Climate impact dimensions

Climate change can affect natural resources, human values and societies in multiple ways, either directly through weather-related phenomena such as extreme events and natural disasters, or indirectly through gradually changing environmental conditions. Generally, the effects of a changing climate on natural resources, human needs and society are considered to be negative in many regions of the world ($N_C < 0$, $H_C < 0$, $S_C < 0$). The degree to which this occurs depends on the vulnerabilities, risks, adaptive capacities, and responses of these systems, which are addressed in more detail below.

Vulnerability and adaptation

The impact of climate change on systems, persons or social groups depends on their vulnerability to loss (damage, harm, and hazard). According to the Oxford English Dictionary (Oxford 2009) a system is vulnerable (from Latin *vulnerare* 'to wound') if it is exposed to being attacked or harmed. This implies that events or acts may interfere with the normal operation of a system in a negative way. Blaikie et al. (1994) state that 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." Thus, vulnerability depends on the person, the type of event, and the actions taken against the hazard. Some persons may be more vulnerable to the same event than others, and some may not be vulnerable at all. An event causing vulnerability may be compensated for by responses to protect against or avoid it in the first place.

There is a range of different interpretations of vulnerability (Adger et al. 2009; Brauch 2006b, 2005). For Ionescu (2009) vulnerability depends on: (1) the entity that is vulnerable, (2) the stimulus to which it is vulnerable, and (3) the preference criteria to evaluate the outcome of the interaction between the entity and the stimulus. The IPCC 2007 defines vulnerability as the "degree, to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." In this understanding, 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." Adaptation is 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". To adapt, a system must have the capacity to respond to a climatic stimulus and to take actions that either diminish harm or compensate for it by establishing positive values.

Implementation of adaptation measures comes at a cost, which compares with the benefits they produce. To operationalize the vulnerability concept, indicators can be developed to measure the intensity of climate change, its harmful impact on various systems and the effectiveness of adaption measures to reduce the harm. In this approach, vulnerability would be the ratio between net damage and the intensity of climate change, which can be reduced by adaptation.[2] The relationship between stimuli, losses and adaptive efforts ultimately depends on the response functions of the respective systems. While in some cases linear responses may be appropriate, non-linear functions may be more adequate in others, such as damped, logistic or threshold responses or bell-shaped curves (Scheffran 2010).

Risks and threats

A risk analysis can be applied to situations with multiple uncertain results to determine the vulnerability to these events in terms of estimated losses and their probability (usually risk is the product of these two variables). To estimate the risks of climate change, information on the expected damage and probability of climate-induced events is needed. Furthermore, data on their timing and measures for risk reduction are useful. Each of the pathways from climate change to societal impacts is associated with a risk that is specific to the persons or systems 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, type of harm for each affected system, and finally the probability for each of the possible responses and societal instabilities. A practical approach is to focus on the essential pathways and develop aggregated risk indicators to measure how countries are potentially affected by climate-related stimuli, including the loss of lives, health, money or natural resources, ranging from moderate to catastrophic risk.

[2] In mathematical terms, for a system with an expected value W and climate change occurring with intensity X causing an expected loss (damage) $Y(X)$, the net value under conditions of climate change would be $V = W - Y(X)$. Vulnerability could be defined as the ratio $y_x = Y(X)/X$, which is the sensitivity of value loss to climate intensity. Mitigation would seek to reduce climate intensity, adaptation would reduce the losses for given intensity where the costs for both play a role (see further Scheffran 2010).

While risk assessments often deal with systemic contexts regarding technical or natural systems and claim a certain degree of objectivity, threat perceptions are often based on subjective attitudes towards an event or person and are usually interpreted as intentional acts that induce fear. During an armed conflict, threat assessments and perceptions are concerned with each other's military capabilities and combine the capability to threaten with the motivation to threaten. Various sources have extended the threat terminology to climate change, e.g. by the phrase "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.

The risks and threats of climate change are quite heterogeneous and influenced by a number of factors, including geographical location, the entity affected, and the social environment. Risk assessments also depend on human knowledge and perception, which in reality are bound to a window of attention, using limited information in terms of their temporal, spatial, social and other dimensions. Impacts and events outside of this window receive less attention.

Security impacts

With the end of the Cold War and increasing globalization, the meaning of security became more comprehensive. It now consists of economic, political, social, and ecological dimensions. In a negative sense, security is the ability to protect against danger, threat, and doubt. In a more positive sense, security means the preservation of core values. Combining both, security is a 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, as well as the capacity to protect against threats. In the emerging new world (dis)order after the Cold War, many actors and factors have been shaping the security discourse in a complex way (Scheffran 2008b). With the conflicting tendencies of globalization and fragmentation, social identities are torn between changing and sometimes contradicting roles and relationships.

Climate change could lead to both, fragmentation or further unification of humanity. Climate security builds on extended 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). If the impacts of climate change provoke responses that affect the entire society, the consequences may also become an issue for national, international or global security, and contribute to securitization. Some climate impacts may cause governments and the military to take actions, e.g. for disaster management, in response to massive refugee flows, or in conflicts induced by environmental stress.

Risk indicators measure how countries are affected by weather-related loss events. E.g., the *Climate Risk Index* developed by Anemüller (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; Alcamo/Endejan 2002).

Interaction between systems and actors

Stability and instability

During the bipolar East-West conflict, stability was a prominent concept in international security and arms control. In the complex world (dis)order that followed in the aftermath of the Cold War, various instabilities emerged (Scheffran 2008b). Facing an economic crisis and the spread of destabilizing factors, the world is confronted with an ”axis of upheaval” (Ferguson 2009). 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 1987). Stability refers to a change in qualitatively different systemic conditions, like a transition from peace to war, from conflict to cooperation, or from environmental destruction to sustainability.

Sensitivity is a key term in the stability concept. If a system is more sensitive to changing conditions, it is more likely to become unstable if there is no correcting mechanism that maintains its stability. The sensitivities between key variables and responses can be combined in an interaction matrix, which can either be mathematically stable or unstable.[3] If climate change affects the stabilizing mechanisms of a social system, it can become potentially unstable. Depending on the given sensitivities, a climate-related event can induce a major destabilizing development in society or even trigger a cascading sequence of events leading to a collapse of society or a more stable situation. Depending on the type of systems, disturbances and responses, various approaches to address the concept of stability can be considered in the climate context.

- **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.” Conditions for environmental and economic stability determine tolerable windows for the allowable speed and magnitude of climate change (Petschel-Held et al. 1999). Ecosystems have adaptive capacities within a viability limit beyond which they break down (Aubin/Saint-Pierre 2007). Similarly, economic processes of production and consumption own an inherent resilience against disruption, as can be repeatedly observed in major crises and wars. Within these limits, an economic system is likely to be able to adapt to a long-term gradual climate change.

- **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 for other actors as well. Their responses may further result in insecurity for others. 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 preemptive actions. The degradation of natural resources puts the survival of people at stake, provoking the use of violence to protect key resources against competitors. Instead, a peaceful approach would seek to strengthen

[3] 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 $x_y < 0$, the instability condition would be $x_x\, y_y - x_y\, y_x < 0$, which represents the intuitive notion that the negative mutual impacts exceed the positive self-impact. With different signs of the impact sensitivities and more variables, the mathematical condition can differ (see Scheffran/Hannon 2007).

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 loose credibility and support from the citizens become weak and unable to maintain order. Individuals who experience personal losses of life, income, property, job, health, family, or friends, which threaten their identity, may be more vulnerable to violate established rules, even more if there is only 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, in particular 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 undercut the ability of governments to satisfy the needs of citizens and to provide opportunities for wealth and prosperity, and could augment other problems, such as growing populations, inadequate freshwater supplies, strained agricultural resources, poor health services, economic decline, or weak political institutions. The marginal impact of climate change undermines the problem-solving capacity of societies in climate hot spots, contributing to their collapse.

Conflict and cooperation

Conflict often emerges from incompatible actions, values, and priorities of actors who fail to properly deal with their differences and tensions. Full blown conflicts consume a considerable amount of resources, forcing conflict parties to use extreme actions and violence until either their capacity to act is exhausted or the resources are replenished by outside sources. Conflict resolution can help to reduce the tension and stabilize the interaction between the conflict parties until they learn to adjust their actions or an agreement is reached. Cooperation is a process in which actors adapt their goals and actions in a mutually beneficial way. The transition from conflict to cooperation requires adaptation towards common positions and actions that stabilize the interaction for the benefit of all (Scheffran/Hannon 2007).

To study the link between climate change and conflict, impact diagrams can be used, which depict the interaction between multiple actors (Figure 4). Each actor i is represented by its capabilities (C_i) that he applies to change the environment (given here by systems x and y). The result of the actions is observed and evaluated using a value function (V_i), which determines the change of actions based onto internal decision rules and priorities (P_i). The actors are interconnected directly through communication processes to exchange information, or through the impacts of each other's actions on the systems' environment. Linkages between the actors are given by the sensitivities, which determine how the value of one actor is affected by the efforts of all actors, which in turn depend on their own decision rules and action priorities. If the mutual sensitivities are negative, this corresponds to a hostile or conflicting relationship. Each actor's actions lead to losses for the other. However, if they are positive the relationship is friendly or cooperative and thus beneficial to both. In addition, the self-impacts have to be considered, i.e. how an effort of one actor affects his/her own value. Using these sensitivities it is possible to determine the structure of the social network between multiple actors, which is connected to the environmental system dynamics they are embedded in.

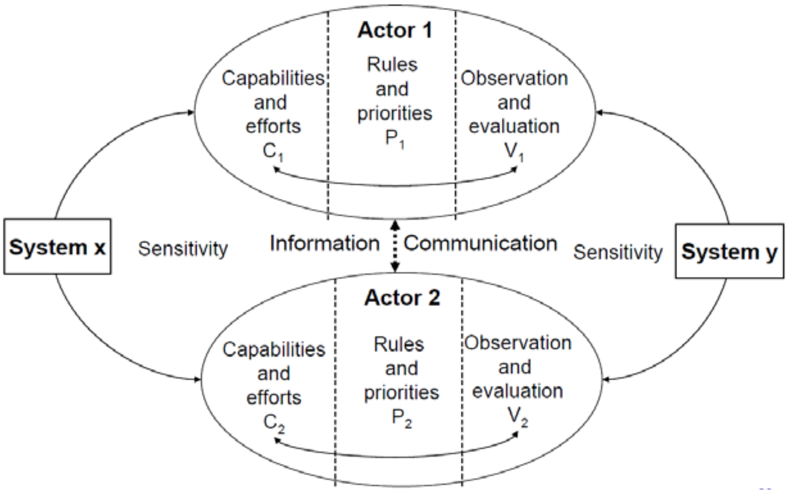

Figure 4: Interaction between two actors and two systems (Scheffran 2010).

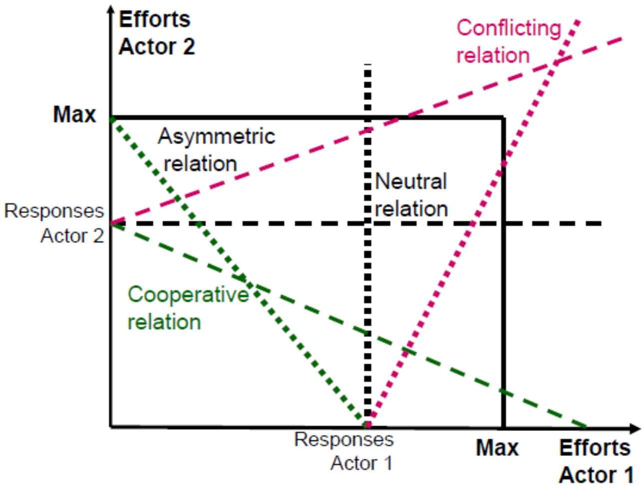

Figure 5: Conflicting and cooperative relationships between two actors taking efforts to reach their individual value goals on the basis of given action rules. Modified from Scheffran/ Hannon (2007).

Whether conflict or cooperation prevails in social interaction depends on the responses of each actor that are determined by the decision rules and action priorities, and the potential for learning and adaptation. There are different types of response functions (Figure 5) that show how the efforts of one actor to achieve a certain value goal are related to the efforts of another actor. If the actions are disconnected and independent of each other, effort is not influenced by other actors and thus kept constant as long as the own goal does not change (neutral relation). In a competitive relationship, effort is increased to compensate for the effort of the other actor and both experience a loss, while in a cooperative situation both benefit from each other and the efforts may decrease accordingly for the same goal. In the mixed cases, one actor cooperates and the other does not, which in some cases may be still better than mutual conflict. In a competitive case, a point of mutual agreement is possible, but the question is whether that point is within the admissible range of maximum efforts. If agreement is not possible for admissible efforts, there is an unresolved conflict unless actors add more resources 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 the other actor. This increases the likelihood of reaching an agreement.[4]

Assume two actors are a developed and a developing country, investing their budgets (serving as efforts) into different energy paths to produce goods that contribute to economic wealth (value). The more they invest into fossil fuels to increase wealth, the more they contribute to climate change, which causes losses to both actors. Accordingly, the agreement point moves further upwards until value goals are no longer feasible for both despite maximum efforts. In this case, actors could be tempted to use violence, either to acquire a higher resource share or to harm the competitor. As an alternative, actors could switch to alternative energy sources to produce economic wealth with fewer carbon emissions and thus less climate losses. In this case, both would cooperate to lower their costs, e.g. by transfer of low-emission technology (Ipsen et al. 2001). Now the agreement point moves inward.

This framework allows the assessment of a wide spectrum of possible scenarios, based on assumptions of the various sensitivities for action alternatives and involving more than two actors to discuss collective action problems. A degradation of the environment that affects the interests and values of some actors shapes conflicts in one or the other way. Environmental change may increase violent conflict or spur cooperation to resolve common problems. Whether climate risks undermine international security and become a source of major conflicts depends on the responses and learning mechanisms of the actors involved, which are shaped by the societal structures, institutional frameworks, and political strategies.

Interactive laboratory for climate security analysis

Overall framework

To build a basis for future analysis, the multi-layer climate-society interaction will be integrated into an interactive laboratory for climate security analysis (*CLISEC Lab*) that can be applied to study the regional climate hot spots. The *CLISEC Lab* will integrate three modules:

1. **Data analysis:** A data-base of typical constellations for climate-society interaction and security syndromes in regional hot spots is combined with response patterns of human actors to environmental change and with tools for statistical analysis to identify key linkages usable in impact graphs. A variety of data sources are used to determine factors of conflict and environmental change in the regions of concern, including historical and current databases, [5]

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[4] In mathematical terms, let sensitivities $f_{11} > 0$ and $f_{22} > 0$ be the positive efficiencies (self-impacts) of the efforts C_1 and C_2 of actors 1 and 2 regarding their own values V_1 and V_2, and $f_{12} < 0$ and $f_{21} < 0$ be the negative mutual impacts on each other's values. Then this would be a competitive interaction and 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 agreement 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 $f_{11} f_{22} - f_{12} f_{21} < 0$, an agreement point does not exist and the conflict escalates to utmost efforts, unless actors do not change their goals.

[5] This includes but is not limited to data from the following sources: Peace Research Institute Oslo data on armed conflict; Uppsala Conflict Data Program Non-State Conflict Dataset; Correlates of War (COW) Project at 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 Center for Research on the Epidemiology of Disasters, Louvain, World Health Organization's (WHO)

news, workshops, focus groups, and selected surveys where necessary. Macro-level databases provide the background information for the micro-level analysis. This requires additional data on the history and current change in key conflict and environmental variables, such as the number and location of societal instability events (e.g. riots, use of massive violence, police and military action), weather-related disasters, per-capita water and food production and consumption, land use, energy use by type, income, and economic growth. More detailed data and estimates about local perceptions and response patterns can be acquired by establishing contacts to people in the regions studied, through workshops, focus groups and field research. Statistical multivariate analyses of previous cases help to determine how best to extract key relationships and potential destabilizing events, generated by the accumulated changes in human living conditions.

2. **Modeling and simulation:** An impact and response model is developed to study emerging complex social phenomena that include conflict, cooperation, and coalition formation, with a focus on the link between climate change and security. This field of research is particularly appropriate to combine systemic approaches (such as ecosystem analysis) and agent-based approaches (to study socio-economic interactions) to facilitate the use of modeling and computational tools in stakeholder support (Scheffran 2006). To apply the framework to specific systems and regions based on previous work (Scheffran 2002, 1999; Scheffran/Jathe 1996), impact graphs are constructed to analyze not only to the interaction between systems (which is the established approach in integrated systems analysis) but also between actors and systems, and among actors. Impact graphs provide a visual representation of cause-effect chains between crucial factors and actors that influence the impact of environmental change on conflict and security. Such a modeling tool makes it possible to generate and test data-generated scenarios and hypotheses.

3. **Decision support and strategy development:** Results from the data and modeling modules provide a basis to extract key indicators in a form that is useful for decision makers and stakeholders. This includes indicators for vulnerability, risk, security, stability, conflict, adaptive capacity, and conflict resolution, which can be presented in security diagrams. Such an analysis provides a basis for developing adaptive strategies for mitigation and adaptation that contain these sensitivities, minimize security risks and mitigate conflicts by strengthening institutions, economic wealth, energy systems, and other critical infrastructures. The results, tools and connections created in this process may also facilitate partnership with and participation of researchers and stakeholders in the regions of concern and also strengthen regional and global governance structures that build climate security and international cooperation.

Modeling approaches and syndrome analysis

Modeling and computer simulation are useful instruments to assess the climate-society interaction. Besides established methodologies, such as dynamical systems theory, decision analysis and game theory, various tools have been developed in complex systems science that allow analyses of the emergence of collective action in social systems. Therefore, they are adequate for participative modeling in stakeholder environments (see Scheffran 2006).

Collaborating Centre for Research on the Epidemiology of Disasters. In addition, the Cline Center for Democracy at the University of Illinois operates an event database, including societal instability indicators, which is being expanded to include environmental, weather and climate-related data.

1. *Agent-based modeling (ABM)* analyzes patterns of collective action emerging from large numbers of agents following particular rules of behavior, including conflict, cooperation and coalition formation (Billari et al. 2006).

2. *Social network analysis (SNA)* describes the connectivity of nodes and links between agents and is appropriate for the structural analysis of social interaction and conflict (Flint et al. 2009; Wasserman/Faust 1995).

3. *Geographic Information Systems (GIS*) use advanced computational tools and database management to represent human interaction in a spatially explicit manner.

4. *Viability theory* provides mathematical methods and tools to maintain controlled system dynamics within viable constraints, given by objective limits or value-based judgments (Aubin/Saint-Pierre 2007). Furthermore, it can be used to predict the confinement of the resource dynamics to a pre-defined domain in phase space, e.g. given by tolerable windows for guardrails of greenhouse gas concentrations (Petschel-Held et al.1999). This makes it possible to identify the necessary control mechanisms to remain within sustainable limits for carbon emissions, and to avoid dangerous climate change.

5. *Qualitative modeling* considers the dynamics of uncertain and fuzzy variables. Normally, it is possible to only estimate the direction or sign of couplings between such variables, thus only qualitative cause-effect relationships can be formulated (Eisenack et al. 2007). The resulting interaction matrix can be examined regarding its stability to identify possible cascading events and existing tipping points.

The syndrome approach is based on qualitative modeling. This approach is suitable for classifying dynamical systems and to find solutions with similar properties. Then rules about the interrelationship of natural processes and human actions can be formulated, which are robust to uncertainties and parameter changes. Qualitative approaches can be useful in mediated modeling involving stakeholders, since they combine system patterns and policy options. The syndrome concept describes typical patterns of global environmental change, based on qualities and dynamic interactions that are perceived as relevant by stakeholders and decision makers.

An example is the overexploitation of marine resources, a pattern associated with the loss of marine biodiversity, overcapitalization, and declining coastal economies (Eisenack/Kropp 2001). The relationships between the individual parts of the system are expressed by general statements of the form: "*If harvest increases and stock regeneration decreases, then the fish stock decreases*", or "*the stronger the pressure of the fishing lobby, the higher the total allowable catch*".

Another syndrome linked to climate change is the Sahel syndrome. This syndrome is characterized by an overcultivation of marginal land leading to negative effects such as soil degradation, desertification and loss of biodiversity (WBGU 1996).

Regional participatory assessment: human perceptions and responses

Human beings, their interests and capabilities, their knowledge and perception, and their responses, interactions, and decisions are the key for dealing with the problem of climate change and their associated risks such as insecurity and conflict. It is essential to include experts and stakeholders from the regions of concern in a participatory assessment of climate impacts to discuss the key links and variables of the climate-society interaction and their measurement (Stoll-Kleemann/Welp 2006). This serves as a starting point for the generation of relevant data and the implementation of an appropriate methodology, taking into account the susceptibility to climate change and varying political, economic, and social conditions. It is uncertain, how adaptation strategies influence security issues and socio-political aspects. Interactions between the overall political environment, socio-economic factors, and climate change are complex and so far lack in-depth research.

To generate data that are useful for identifying possible future events and structures, selected conflict constellations influenced by climate change need to be tested concerning their relevance. Involving stakeholders and focus groups in mapping exercises in the regions of concern is important in order to detect to what extent climate-related security risks are already reflected in national adaptation and planning processes. Impact graphs for the critical factors and actors include climate-induced events and impacts, human responses and interactions, feedbacks, societal consequences, and instabilities. This helps to discover the essential network of interactions depending on the complexity of the situation and to discuss the key information deficits and needs for additional data. These would have to be acquired by selected surveys and field research.

Focus groups have turned out to be successful in various contexts as a process of group discussion and evaluation of critical societal issues, strengthening participatory approaches to environmental governance (concerning the concept see Scheffran/Stoll-Kleemann (2003) regarding climate change e.g. Bürki (2000)). In this context, focus groups are appropriate to assess climate impact graphs with respect to their relevance for the security in the region, and to identify and analyze the relationship between environmental change and socio-political trends. Focus groups bring together people affected by environmental change (e.g. migrants) in order to evaluate possible social responses to these changes and policy makers who are also questioned about their estimates of certain ecological and socio-political trends. Furthermore, such interviews combine homogenous groups of stakeholders to explore their attitudes and evaluations on issues of climate-change related security threats.

Cases of regional climate security hot spots

The Mediterranean region

The Mediterranean region (Southern Europe, North Africa, and 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 losses of snow and glacial melt water. This adds to existing problems of desertification, water scarcity, and food production (Brauch et al. 2003; Giannakopoulos et al. 2005; IPCC 2007; Stern et al. 2006). 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 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 that include high population growth, a substantial dependence on agriculture and weak governance.

The Middle East is plagued by deeply-rooted violent conflicts and by a lasting water scarcity (Amery 2000; Biswas 1994; Shuval/Dweik 2007; Wolf 1995). 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 on "water wars" have been questioned (Libiszewski 1995). Competition over shared resources has been observed for the rivers Nile, Euphrates and Jordan. The Jordan River basin has been considerably contested among Israel, Jordan, Lebanon, Syria, and the Palestinians, raising issues of equity (Phillips et al. 2006) . 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 the change in behavior towards cooperation. Besides technical and economic solutions that 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 the transboundary water data (Medzini/Wolf 2004). However, the long history of conflicts has resulted in deep distrust in the region, which impairs the chance of cooperation (Brown/Crawford 2009).

Case study: Egypt and water conflicts in the Nile River basin

Reduced water supply over an extended period bears a conflict potential for the countries in the Nile basin (Mason 2004). Egypt depends on the Nile for 95% of its drinking and industrial water and could feel threatened by upstream countries that deplete the water resources from the river. While this increases the chances for political crisis and violent clashes (Brauch 2006a), it also increases the necessity 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. However, the agriculturally quite productive river delta is at risk from sea-level rise and salinization (WBGU 2007).

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 climate change induced water scarcity and land degradation. Wheat and maize production in Egypt could significantly drop by middle of the 21st century. Even without the continuing mounting demographic pressure, this may intensify competition over 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 even worsen existing problems. A 0.5m rise of the sea level of the Mediterranean Sea will displace between two and four million Egyptians (FoEME 2007). Most of them will seek refuge in Cairo's suburbs. Water scarcity and lower agricultural productivity in the Upper Nile area may also add to migration from the rural areas to Cairo and contribute to degradation of sanitary conditions and increasing social unrest as well.

The interactions and causal relationships between the various driving factors influencing societal stability can be visualized in an impact diagram. As an example, Figure 6 shows some of the most important relationships between system variables and key actors. A green arrow indicates a positive feedback, i.e. an increase of one factor causes an increase in the factor that is affected. A red arrow represents a negative feedback, which implies that an increase in a particular variable leads to a decline in the variable that is affected. A black arrow represents a feedback that is ambivalent. No arrow implies that no relevant impact is considered

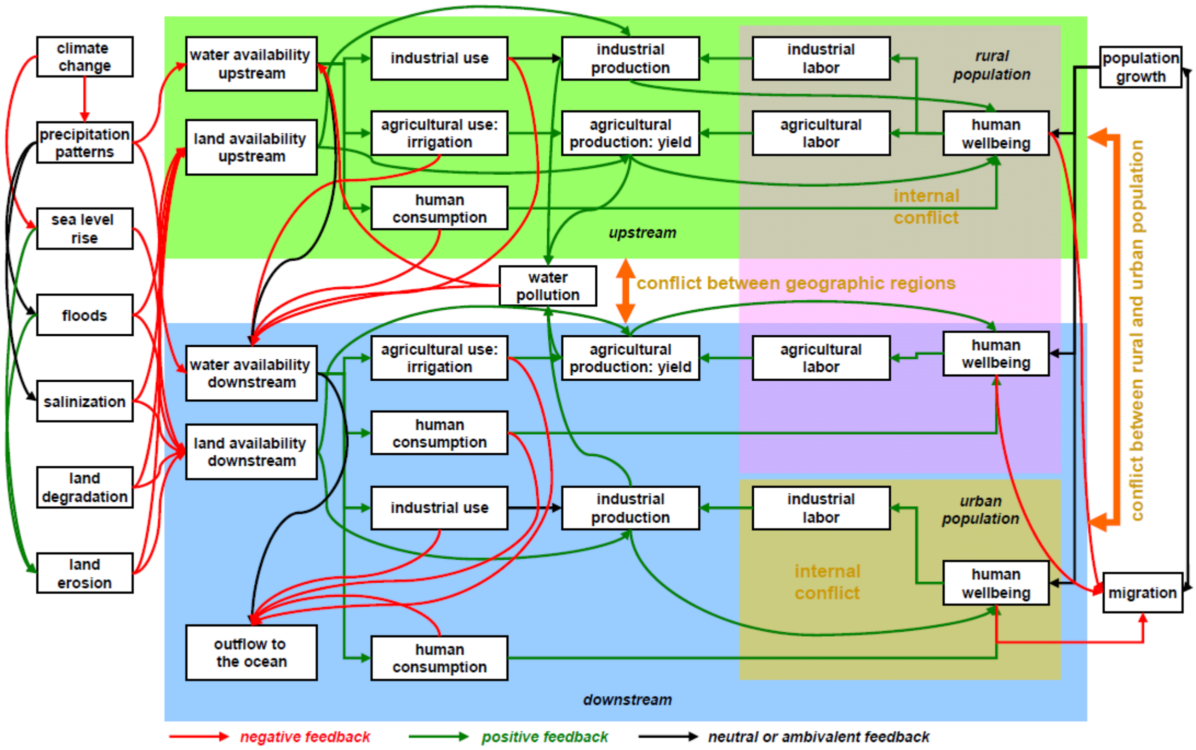

Figure 6: Schematic overview of the water conflict in the Nile River basin.

Figure 6 shows the essential relationships of the water conflict in the Nile region in an impact diagram. Changes in environmental conditions have an influence on water and land availability, which in turn affects economic production. Since human welfare and consequently societal stability depend on wealth, any deterioration of the economy has negative implications on society as well. Since the water availability and thus the conditions for agricultural production depend on the water use further upstream, two main geographic regions (upstream and downstream) are distinguished. Also, there is a differentiation between the population of rural and urban areas along the Nile River, as economic activities differ substantially and the effects of climate change vary accordingly. Any large scale change in the structure of society, which may be 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 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 regions. These may increase in intensity if migration between these regions or particularly large population growth leads to larger competition of 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.

Case study: The Sahel Syndrome and land use conflicts in Northern Africa

A notable example of how climate impacts may possibly interfere with security is land use conflicts in Northern Africa. For decades, 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, which forced increased migration of nomadic groups from adjacent countries into the more fertile areas. This has contributed to the current struggle for land between herders and farmers as Arabic herders from the north migrated southward in the dry season in search of water sources and grazing for their cattle. However, this destroyed the fields of African farmers. The increased influx of competitors, combined with tougher living conditions during the drought, has led to clashes and tensions between the newcomers and the local farmers (International Commission of Inquiry on Darfur 2005). In addition, a series of drought events affected the Northern African regions since the 1970s and the fight for the scarce resources has become more intense. UNEP (2007) estimates that the boundary between semi-desert and desert has moved southward by an estimated 50 to 200 km since the 1930s, and it will continue to move due to further diminishing precipitation. The predicted loss in agricultural land is expected to lead to a significant drop in food production on the order of 20%. A reduced availability of water and land caused by climate change does not directly nor necessarily increase the conflict potential, but rather causes diverse feedbacks within and between the group of farmers and herders. These are shown in Figure 7.

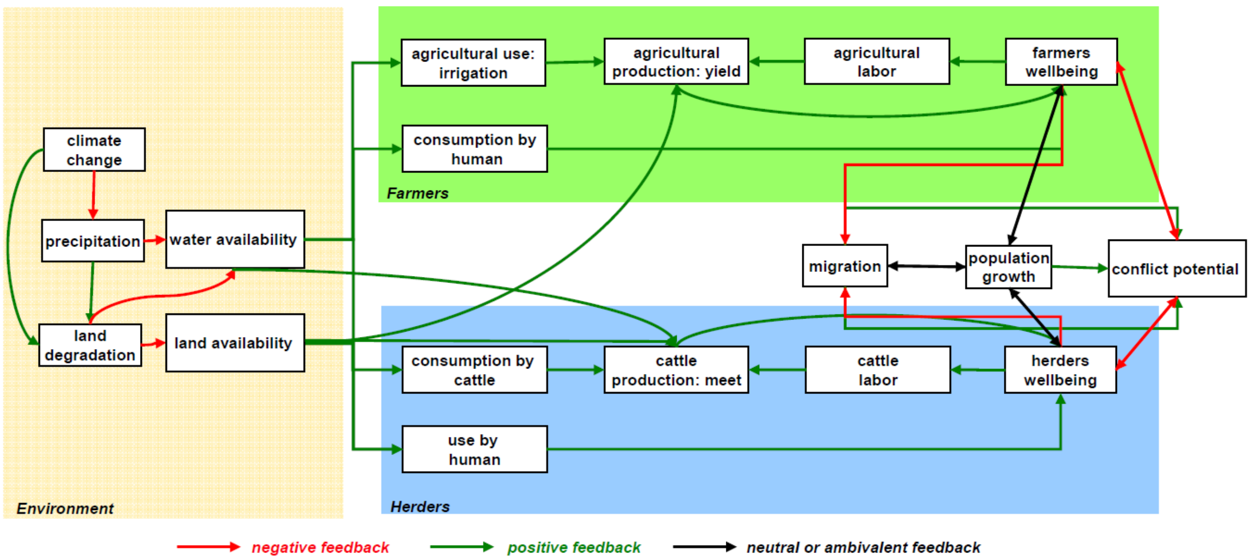

Figure 7: Schematic overview of the water and land use conflict in Northern Africa.

Such interactions between farmers and herders can be viewed as a contributing factor in the conflict in the Darfur region of Sudan. This conflict has a number of root causes, among which the environment may be only secondary. The internal conflict between the North and the South has started in 1983, involving serious human rights abuses and humanitarian disasters. More than 2 million people have died during the conflict and 4.5 million individuals were forced to leave their homes (International Commission of Inquiry on Darfur 2005). Inter-tribal conflict was further aggravated by access to weapons, partly fueled by oil revenues. The decision of the government to arm the Janjaweed militia against the rebels has escalated to a full-scale civil war. International involvement has pushed for a Comprehensive Peace Agreement (International Crisis Group 2004), which yet remains weak.

So far, the importance of changes in climatic conditions as a key driving factor in conflicts such as the Darfur conflict could not be clearly determined. A study by Sandia Research Labs assesses the role of climate factors in these conflicts (Boslough et al. 2004). This empirical analysis, which is based on O'Brien (2002), shows statistical correlations between conflict instability and various indicators, such as income and calories per capita, life expectancy, youth bulge, infant mortality rate, trade openness, ethnic composition of the population, political freedom, and democratic rights. While some of these factors tend to worsen the conflict constellation, a clear overall message could not be provided. The Sudan Post-Conflict Environmental Assessment of the UN Environmental Programme concludes on the basis of an extensive expert assessment (UNEP 2007) that critical environmental issues, including land degradation, deforestation and the impacts of climate change, threaten the Sudanese people's prospects for long-term peace, food security, and sustainable development. To reduce the chances for local conflicts over natural resources and to support lasting peace, the report suggests considerable investments in environmental management, admitting that environmental factors are intertwined with a range of other social, political, and economic issues, which have to be addressed to ensure societal stability.

Strategies to prevent climate security risks and conflicts

Climate change confronts humanity with multiple security risks and major challenges to its problem-solving capacities. The magnitude of the potential risks of climate change requires determined policies to manage global change within a new well-designed global governance system that combines sustainable environmental policy, development policy and preventive security policy. A global diplomacy is required to contain climate-induced conflicts, develop compensation mechanisms for those affected by climate change, implement global migration policy, and measures to stabilize the world economy (WBGU 2007).

Avoiding climate security risks and mitigating conflicts induced by climate change requires an integrated set of strategies that address both the causes as well as the impacts of climate change. Any long-term climate strategies have to consider the time lag between emission reductions and their impact on the climate system and the social system (Scheffran 2008a). The longer the time horizon of decision making, the larger the uncertainties policymakers have to deal with (Lempert et al. 2009). There is deep uncertainty in our understanding of climate thresholds when systems models and probability functions are unknown.

The conceptual framework described in the previous sections provides a guideline to develop strategies and approaches that address the climate challenges to society, stability and security. Figure 8 shows an approach that combines the strengthening of economic welfare, human capability, and sustainable development with strategies that reduce vulnerabilities and risks. The central objective is to establish the core functions of a world society through adaptive and participative governance.

Future research will aim at a comparative assessment of climate impacts on human security and societal stability in climate hot spots. Analyzing the international security and conflict dimensions is a precondition to develop science-based integrated strategies and solutions that help to strengthen the link between peace and sustainability. These comparative analyses will focus on indicators to measure and discuss the security impact of climate change in different regions of the world.

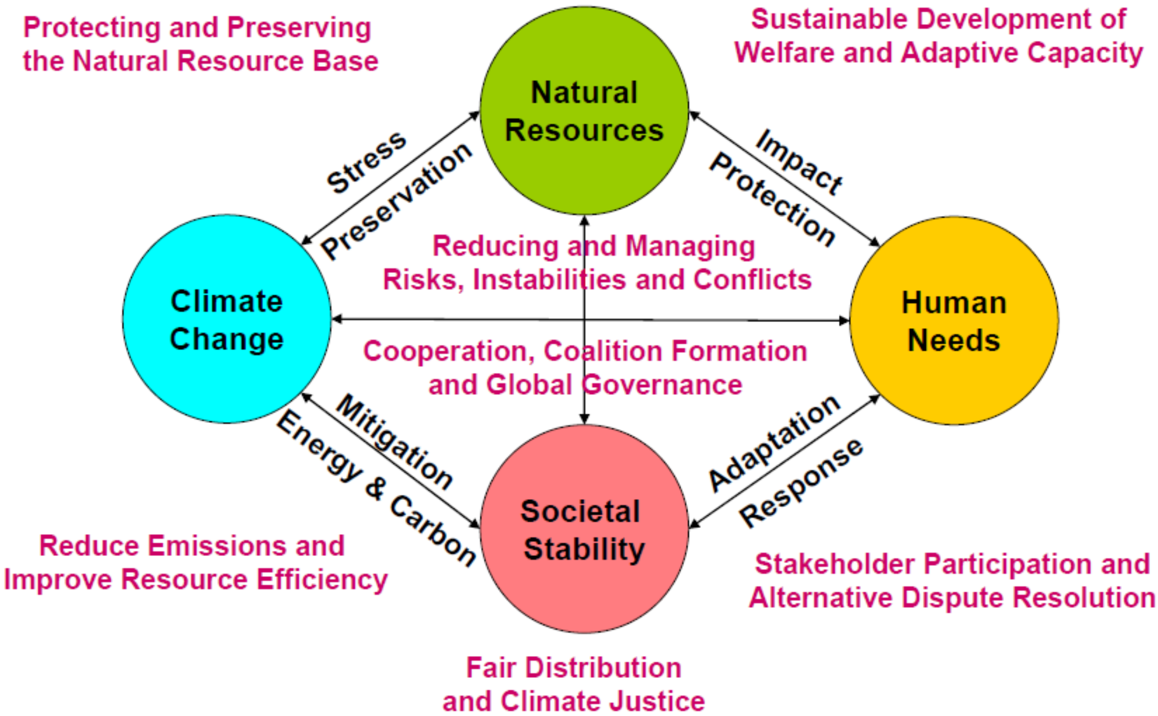

Figure 8: Strategies for dealing with climate security risks and conflicts (Scheffran 2010)

Useful indicators include the impacts of climate-related events in terms of the risks these events pose. This provides the likely expected damage without adaptation, which is a function of the vulnerability and sensitivity of a region with regard to the climate-related event. Furthermore, the adaptive capacity of the region to climate-related events, in terms of the risk reduced by adaptation, is of interest. Also, the intensity of conflicts arising from climate-related events varies. This is an important quantity as it takes into account the existing conflict potential and increase or decrease by the events. Possible indicators are the force used or the casualties produced as a result of violent acts. Finally, it is worthwhile to know which solutions could diminish violent conflict using cooperation, conflict resolution and security policy to prevent, manage or resolve a violent conflict.

All the data acquired from statistical assessments, historic queries and in situ interviews are combined in a database, which then serves as a basis for numerical conflict models that are used to assess the societal stability for different scenarios of future climatic and demographic developments. These can then be used to identify potential tipping points or critical situations that lead to societal instability. Climate change poses a wide variety of challenges to humankind. Adaptation to the pronounced environmental changes can only be successful if societies avoid getting entangled in violence and conflict by implementing appropriate political strategies. Models linking potential climate change scenarios with anthropogenic actions and interactions provide a useful tool to aid decision makers in the development of such strategies.

References

Adger, W. Neil; Lorenzoni, Irene; O'Brien, Karen (Eds.), 2009: *Adapting to Climate Change: Thresholds, Values, Governance* (Cambridge: Cambridge University Press).

Alcamo, J.; Acosta-Michlik, L.; Carius, A.; Eierdanz, F.; Klein, R.; Kromker, D.; Tänzler, D., 2008: "A new approach to quantifying and comparing vulnerability to drought", in: *Regional Environmental Change*, 8,4: 137-149.

Alcamo, Joseph; Endejan, Marcel, 2002: "The Security Diagram - An Approach to Quantifying Global Environmental Security", in: Petzold-Bradley, Eileen; Carius, Alexander; Vinvze, Arpád (Eds.): *Responding to Environmental Conflicts - Implications for Theory and Practice* (Dordrecht: Kluwer Academic Publishers): 133-147.

Amery, A., Wolf, A., 2000: Water in the Middle East: A Geography of Peace (Austin: University of Texas Press).

Anemüller, Sven; Monreal, Stephan; Bals, Christoph, 2006: Global Climate Risk Index 2006 (Bonn: Germanwatch); at: <http://www.germanwatch.org/klak/kri2006.pdf>.

Aubin, Jean-Pierre; Saint-Pierre, Patrick, 2007: "An introduction to viability theory and management of renewable resources", in: Kropp, Jürgen; Scheffran, Jürgen (Eds.): *Decision Making and Risk Management in Sustainability Science* (New York: Nova Science): 43-80.

Barnett, J., 2003: "Security and climate change", in: *Global Environmental Change-Human and Policy Dimensions*, 13,1: 7-17.

Barnett, J.; Adger, W. N., 2007: "Climate change, human security and violent conflict", in: *Political Geography*, 26: 639-655.

Billari, F.; Fent, T.; Prskawetz, A.; Scheffran, J. (Eds.), 2006: Agent Based Computational Modelling in Demography, Economic and Environmental Sciences (Heidelberg: Springer/Physica).

Biswas, A. (Ed.), 1994: International Waters of the Middle East: From Euphrates-Tigris to Nile (Oxford: Oxford University Press).

Blaikie, Piers; Cannon, Terry; Davis, Ian; Wisner, Ben, 1994: *At Risk: Natural Hazards, People's Vulnerability, and Disasters* (London: Routledge).

Boslough, M.; Sprigg, J.; Backus, G.; Taylor, M.; McNamara, L.; Fujii, J.; Murphy, K.; Malczynski, L.; Reinert, R., 2004: Climate Change Effects on International Stability: A White Paper; at: <http://est.sandia.gov/earth/docs/Climate_white_paper.pdf>.

Brauch, H.G.; El-Sayed Selim, M.; Liotta, P.H.; Chourou, B.; Rogers, P., 2003: Security and the Environment in the Mediterranean (Berlin: Springer).

Brauch, Hans Günter, 2005: Threats, Challenges, Vulnerabilities and Risks in Environmental Human Security (Bonn: UNU-EHS); at: <http://www.ehs.unu.edu/index.php?module=overview&cat=17&menu=36>.

Brauch, Hans Günter, 2006a: Regionalexpertise - Destabilisierungs- und Konfliktpotential prognostizierter Umweltveränderungen in der Region Südeuropa und Nordafrika bis 2020/2050. Expert Study for the German Advisory Council on Global Change; at: <http://www.wbgu.de/wbgu_jg2007_ex01.pdf>.

Brauch, Hans Günter, 2006b: Security Threats, Challenges, Vulnerability and Risks, in: Oswald Spring, Ú. (Ed.): International Security, Peace, Development, and Environment (EOLSS Publishers).

Brauch, Hans Günter, 2009: "Securitizing Global Environmental Change", in: Brauch, H.G.; Behera, N.C.; Kameri-Mbote, P.; Grin, J.; Oswald Spring, Ú.; Chourou, B.; Mesjasz, C.; Krummenacher, H. (Eds.): Facing Global Environmental Change: 65-102.

Brown, O.; Crawford, A., 2009: Climate Change and Security in Africa. A Study for the Nordic-African Foreign Ministers Meeting (Winnipeg/Geneva: International Institute for Sustainable Development).

Brown, Oli, 2007: Weather of Mass Destruction? The rise of climate change as the `new´ security issue (London: International Institute for Sustainable Development); at: <http://www.iisd.org/pdf/2007/com_weather_mass_destruction.pdf>.

Brzoska, Michael, 2009: "The Securitization of Climate Change and the Power of Conceptions of Security", in: *Security and Peace*, 27,3: 137-145.

Bürki, Rolf, 2000: Klimaänderungen und Anpassungsprozesse im Wintertourismus (St. Gallen: Ostschweizerische Geographische Gesellschaft).

Campbell, Kurt M.; Gulledge, Jay; McNeill, John R.; Podesta, John; Ogden, Peter; Fuerth, Leon; Woolsey, R. James; Lennon, Alexander T.J.; Smith, Julianne; Weitz, Richard; Mix, Derek, 2007: *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change* (Washington, D.C.: Center for Strategic and International Studies).

Carius, Alexander ; Tänzler, Dennis; Maas, Achim, 2008: *Climate Change and Security - Challenges for German Development Cooperation* (Eschborn: Gesellschaft für technische Zusammenarbeit [GTZ]).

CNA [The CNA Corporation] 2007: *National Security and the Threat of Climate Change* (Alexandria: VA: Center for Naval Analysis); at: <http://securityandclimate.cna.org/>.

Eisenack, K.; Kropp, J.P., 2001: "Assessment of Management Options in Marine Fisheries by Qualitative Modelling Techniques", in: *Marine Pollution Bulletin*, 43,7-12: 215-224.

Eisenack, K.; Lüdeke, M.K.B.; Petschel-Held, G.; Scheffran, J.; Kropp, J.P., 2007: "Qualitative Modelling Techniques to Assess Patterns of Global Change", in: Kropp, J.P; Scheffran, Jürgen (Eds.): Advanced Methods for Decision Making and Risk Management in Sustainability Science (New York: Nova Science): 99-146.

European Commission, 2008: Climate Change and International Security - Paper from the High Representative and the European Commission to the European Council (Brussels: European Commission); at: <http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf>.

Ferguson, Niall, 2009: "The Axis of Upheaval", in: *Foreign Policy*, 171: 56-58.

Flint, Colin; Diehl, Paul; Scheffran, Jürgen; Vasquez, John; Chi, Sang-hyun, 2009: "Conceptualizing ConflictSpace: Towards a geography of relational power and embeddedness in the analysis of interstate conflict", in: *Annals of the Association of American Geographers*, 99,5: 827-835.

FoEME, 2007: Climate Change: A New Threat to Middle East Security; at: <http://www.foeme.org/index_images/dinamicas/publications/publ78_1.pdf >.

Giannakopoulos, C.; Bindi, M.; Moriondo, M.; LeSager, P.; Tin, T., 2005: Climate change impacts in the Mediterranean resulting from a 2°C global temperature rise. Study commissioned by WWF (Gland).

Hare, B., 2006: "Relationship Between Increases in Global Mean Temperature and Impacts on Ecosystems, Food Production, Water and Socio-Economic Systems", in: Schellnhuber, H.J.; Cramer, W.; Nakicenovic, N.; Wigley, T.; Yohe, G. (Eds.): Avoiding Dangerous Climate Change (Cambridge: Cambridge University Press): 177-186.

International Commission of Inquiry on Darfur, 2005: Report of the International Commission of Inquiry on Darfur to the UN Secretary-General (Geneva International Commission of Inquiry on Darfur); at: <www.un.org/News/dh/sudan/com_inq_darfur.pdf>.

International Crisis Group, 2004: ICG Africa Report No. 80. Sudan: Now or Never in Darfur (Nairobi/Brussels: International Crisis Group).
Ionescu, Cezar; Klein, Richard J. T.; Hinkel, Jochen; Kavi Kumar, K. S.; Klein, Rupert, 2009: "Towards a Formal Framework of Vulnerability to Climate Change", in: *Environmental Modeling and Assessment*, 14,1: 1-16.
IPCC [Intergovernmental Panel on Climate Change], 2007: Climate Change 2007. Climate Change Impacts, Adaptation and Vulnerability, Working Group II, Summary for Policymakers (Geneva: Intergovernmental Panel on Climate Change).
IPI [International Peace Institute] 2009: Climate Change is a Threat Multiplier, Experts Say; at: <http://www.ipacademy.org/events/panel-discussions/details/93-climate-change-is-a-threat-multiplier-experts-say.html>.
Ipsen, D.; Rösch, R.; Scheffran, J., 2001: "Cooperation in global climate policy: potentialities and limitations", in: *Energy Policy*, 29,4: 315-326.
Lempert, R.; Scheffran, J.; Sprinz, D. F., 2009: "Methods for Long-Term Environmental Policy Challenges", in: *Global Environmental Politics*, 9,3: 106-133.
Libiszewski, S., 1995: "Water Disputes in the Jordan Basin Region and their Role in the Resolution of the Arab-Israeli Conflict", in: CSS Environment and Conflicts Project (Zürich: Center for Security Studies).
Maas, Achim; Tänzler, Dennis, 2009: *Regional security implications of climate change. A synopsis*. Adelphi Report 01/09 (Berlin: Adelphi Consult).
Mason, Simon A., 2004: From conflict to cooperation in the Nile Basin. Interaction between water availability, water management in Egypt and Sudan, and international relations in the Eastern Nile Basin (Zurich: Swiss Federal Institute of Technologie ETH Zurich).
Medzini, A.; Wolf, A.T., 2004: "Towards a Middle East at Peace: Hidden Issues in Arab-Israeli Hydropolitics", in: *Water Resources Development*, 20,2: 193-204.
Nordås, R.; Gleditsch, N. P., 2007: "Climate change and conflict", in: *Political Geography*, 26,6: 627-638.
O'Brien, S. P., 2002: "Anticipating the Good, the Bad, and the Ugly", in: *Journal of Conflict Resolution*, 46,6: 791-811.
Oxford, 2009: Oxford English Dictionary; at: www.askoxford.com.
Petschel-Held, G.; Schellnhuber, Hans Joachim; Bruckner, Thomas; Toth, Ferenc L.; Hasselmann, Klaus, 1999: "The Tolerable Windows Approach: Theoretical and Methodological Foundations", in: *Climatic Change*, 41,3-4: 303-331.
Phillips, D.; Daoudy, M.; McCaffrey, S.; Öjendal, J.; Turton, A., 2006: Trans-boundary Water Cooperation as a Tool for Conflict Prevention and for Broader Benefit-sharing (Windhoek/Namibia: Phillips Robinson and Associates).
Raleigh, C.; Urdal, H., 2007: "Climate change, environmental degradation and armed conflict", in: *Political Geography*, 26: 674-694.
Scheffran, J., 1999: "Environmental Conflicts and Sustainable Development: A Conflict Model and its Application in Climate and Energy Policy", in: Carius, A.; Lietzmann, K.M. (Eds.): Environmental Change and Security (Berlin: Springer)**:** 195-218.
Scheffran, J., 2002: "Conflict and Cooperation in Energy and Climate Change", in: Holler, M.; Kliemt, H.; Schmidtchen, D.; Streit, M. (Eds.): Yearbook New Political Economy 20, (Tübingen: Mohr Siebeck)**:** 229-254.
Scheffran, J., 2008a: "Climate change and security", in: *Bulletin of the Atomic Scientists*, 64,2: 19-25.
Scheffran, J., 2008b: "The Complexity of Security", in: Scheffran, J. (Eds.): Security and Complexity, Special Issue of the Journal "Complexity", 14,1: 13-21.
Scheffran, J.; Hannon, B., 2007: "From complex conflicts to stable cooperation", in: *Complexity*, 13,2: 78-91.

Scheffran, J.; Jathe, M., 1996: "Modelling the Impact of the Greenhouse Effect on International Stability", in: Kopacek, P. (Eds.): Supplementary Ways for Improving International Stability (Amsterdam: Pergamon): 31-38.

Scheffran, J.; Stoll-Kleemann, S., 2003: "Participatory Governance in Environmental Conflict Resolution", in: Deb, K.; Srivastava, L. (Eds.): Transition Towards Sustainable Development in South Asia (New Delhi: The Energy and Resources Institute): 307-327.

Scheffran, Jürgen, 2006: "Tools for Stakeholder Assessment and Interaction", in: Stoll-Kleemann, S.; Welp, M. (Eds.): Stakeholder Dialogues in Natural Resources Management: 153-185.

Scheffran, Jürgen, 2009: "The Gathering Storm - Is Climate Change a Security Threat?", in: *Security Index*, 87,2: 21-31.

Scheffran, Jürgen, 2010: "The Security Risks of Climate Change: Vulnerabilities, Threats, Conflicts and Strategies", in: Brauch, H. G.; Oswald-Spring, U.; Kameri-Mbote, P.; Mesjasz, C.; Grin, J.; Chourou, B.; Dunay, P.; Birkmann, J. (Eds.): Coping with Global Environmental Change, Disasters and Security (Berlin: Springer).

Schellnhuber, H.J.; Cramer, W.; Nakicenovic, N.; Wigley, T.; Yohe, G. (Eds.), 2006: Avoiding Dangerous Climate Change (Cambridge: Cambridge University Press).

Shuval, H.; Dweik, H., 2007: Water Resources in the Middle East. Israel-Palestinian Water Issues - From Conflict to Cooperation (Berlin: Springer).

Stern, N.; Peters, S.; Bakhshi, V.; Bowen, A.; Cameron, C.; Catovsky, S.; Crane, D.; Cruickshank, S.; Dietz, S.; Edmonson, N.; Garbett, S.-L.; Hamid, L.; Hoffman, G.; Ingram, D.; Jones, B.; Patmore, N.; Radcliffe, H.; Sathiyarajah, R.; Stock, M.; Taylor, C.; Vernon, T.; Wanjie, H.; Zenghelis, D., 2006: Stern Review: The Economics of Climate Change (London: HM Treasury).

Stoll-Kleemann, Susanne; Welp, Martin (Eds.), 2006: Stakeholder Dialogues in Natural Resources Management (Berlin: Springer).

Ter Borg, Marlies; Tulp, Marianne, 1987: Defence Technology Assessment - Improving defence decision making (Amsterdam: Nederlandse Organisatie voor Technologisch Aspectenonderzoek).

UNEP, 2007: Sudan Post-Conflict Environmental Assessment (Nairobi: United Nations Environment Programme).

UNFCCC, 1992: United Nations Framework Convention on Climate Change; at: <http://unfccc.int/resource/docs/convkp/conveng.pdf>.

Wasserman, S.; Faust, K., 1995: Social Network Analysis: Methods and Applications (Cambridge: Cambridge University Press).

WBGU, 1996: World in Transition - The Research Challenge (Berlin: Springer).

WBGU, 2007: World in Transition - Climate Change as a Security Risk - Summary for Policymakers (Berlin: Springer).

WBGU, 2008: World in Transition - Climate Change as a Security Risk (London: Earthscan); at: <http://www.wbgu.de/wbgu_jg2007_engl.html>.

Wolf, A., 1995: Hydropolitics along the Jordan River: The Impact of Scarce Water Resources on the Arab-Israeli Conflict (New York: United Nations University Press).

CLISEC Working Papers

Scheffran, J. (2009): *Climate change, Human Security and Societal Instability: Conflict or Cooperation?*, Paper presented at the Synthesis Conference of the Global Environmental Change and Security program, Oslo, Norway, 22-24 June, 2009. Working paper **CLISEC-1**, Research Group Climate Change and Security, University of Hamburg.

Kominek, J. (2009): *Analysing the path of "using cyclical patterns for interpreting the situation" – a different approach using path dependency theory,* submitted. Working paper **CLISEC-2**, Research Group Climate Change and Security, University of Hamburg.

Scheffran, J., Link, P.M. & Schilling, J. (2009): *Theories and Models of the Climate Security Link,* Paper presented at the Conference "Climate Change, Social Stress and Violent Conflict", Hamburg, Germany, 19-20 November, 2009. Working paper **CLISEC-3**, Research Group Climate Change and Security, University of Hamburg.

Kominek, J. (2009): *Each institutionalization elementary is a self-reinforcing process increasing path dependency,* submitted. Working paper **CLISEC-4**, Research Group Climate Change and Security, University of Hamburg.

Kominek, J. (2009): *A new action model – deducing an 'ideal type path dependent' for scenario simulation,* submitted. Working paper **CLISEC-5**, Research Group Climate Change and Security, University of Hamburg.

Link, P.M., Piontek, F., Scheffran, J. & Schilling, J. (2010): *Integrated Assessment of Climate Security Hot Spots in the Mediterranean Region: Potential Water Conflicts in the Nile River Basin,* Paper presented at the Conference "Climate Change and Security", Trondheim, Norway, 21-24 June, 2010. Working paper **CLISEC-6**, Research Group Climate Change and Security, University of Hamburg.

Kominek, J. (2010): *Global climate policy reinforces local social path dependent structures: More conflict in the world?,* submitted to *Springer Hexagon Series*, Vol. 8. Working paper **CLISEC-7**, Research Group Climate Change and Security, University of Hamburg.

Kominek, J. (2010): *Path dependency: Intense reflexive modeling as 'intelligent herding'?,* submitted. Working paper **CLISEC-8**, Research Group Climate Change and Security, University of Hamburg.

Link, P.M., Piontek, F., Scheffran, J. & Schilling, J. (2010): *Impact of climate change on water conflict and cooperation in the Nile River Basin,* submitted. Working paper **CLISEC-9**, Research Group Climate Change and Security, University of Hamburg.

Link, P.M. & Schleupner, C. (2010): *How do tourists perceive and accept changes in landscape characteristics on the Eiderstedt peninsula?*, submitted to *Coastline Reports*. Working paper **CLISEC-10**, Research Group Climate Change and Security, University of Hamburg.

Alwardt, C. (2011): *Wasser als globale Herausforderung: Die Ressource Wasser*. Working paper **CLISEC-11**, Research Group Climate Change and Security, University of Hamburg.