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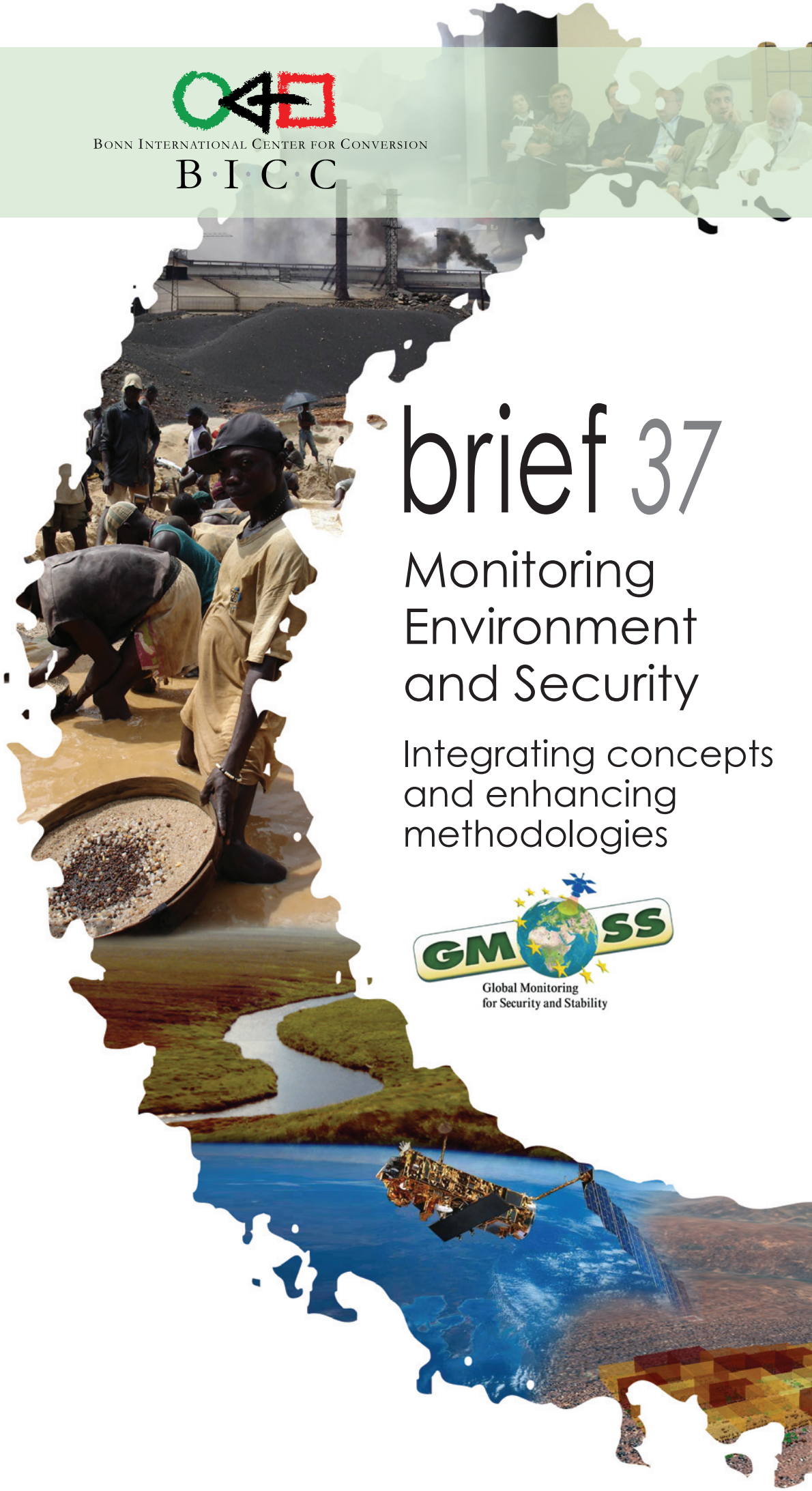

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Monitoring Environment and Security

Integrating concepts and enhancing methodologies

GMOSS

Global Monitoring for Security and Stability

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Monitoring Environment and Security

Integrating concepts and enhancing methodologies

Seminar documentation

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List of Acronyms and Abbreviations

AIACC	Assessment of Impacts and Adaptations to Climate Change
ai	Amnesty International
AOI	Area of interest
BAR	Basins at Risk
BCPR	Bureau for Crisis Prevention and Recovery
CDM	Clean Development Mechanism
CEOS	Committe on Earth Observation Satellites
CFE	Treaty on Conventional Armed Forces in Europe
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CJMC	Ceasefire Joint Military Committee
CNA	Centre for Naval Analysis
COPINE	Cooperative Information Network
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
CSD	Commission on Sustainable Development
CSPs	Country Strategy Papers
CTBT	Comprehensive Nuclear Test-Ban Treaty
CWC	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction
DBMS	Database Management System
DFID	(UK) Department for International Development
DIIS	Danish Institute for International Studies
EC	European Commission
EEA	European Environment Agency
EITI	Extractive Industries Transparency Initiative
ENP	European Neighbourhood Policy
ENVSEC	Environment and Security
EO	Earth observation
EON	Earth Observation for Natura
ESA	European Space Agency
ESPA	Environmental Security for Poverty Alleviation (IES)
ESS	European Security Strategy
EU	European Union
FAST	Früherkennung und Analyse von Spannungen und Tatsachenermittlung / Early Recognition of Tensions and Factfinding
FOI	Swedish Defense Research Institute
GAW	Global Atmosphere Watch
GCC	Global Climate Change
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GDRC	The Global Development Research Center
GEO	Global Environment Outlook
GEO	Group on Earth Observation
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
GMES	Global Monitoring for Environment and Security

GMOSS	Global Monitoring for Security and Stability
GOFC	Global Observation of Forest and Land Cover
GOLD	Global Observation of Land Dynamics
GOME	Global Ozone Monitoring Experiment
GOOS	Global Ocean Observing System
GSE	GMES Service Element
GSI	Guiana Shield Initiative
GTOS	Global Terrestrial Observing System
HDR	Human Development Report
HMA	Heterogeneous Mission Access
ICRC	International Committee of the Red Cross
IDPs	Internally Displaced Persons
IES	Institute for Environmental Security
IGOS	Integrated Global Observing Strategy
ILO	International Labor Organization
INSPIRE	Infrastructure for Spatial Information in Europe
IPCC	Intergovernmental Panel on Climate Change
JDB	Joint Defence Board
JMC	Joint Military Commission
JRC	Joint Research Centre
LHWP	Lesotho Highland Water Project
MAB	Man and Biosphere
MA	Millennium Ecosystem Assessment
MCMC	Markov chain Monte Carlo (method)
MDG	Millennium Development Goal
MEA	Multilateral Environmental Agreement
MICROCON	Micro Level Analysis of Violent Conflicts
NATO CCMS	NATO Committee on the Challenges of Modern Society
NGO	Non-governmental organizations
NoE	Network of Excellence
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NSS	National Security Strategy
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OSCE	Organisation for Security and Co-operation in Europe
PCCP	from Potential Conflict to Cooperation Potential
PCDMB	Post-Conflict and Disaster Management Branch (UNEP)
PRECIS	Providing Regional Climates for Impact Studies
PRIO	International Peace Research Institute, Oslo
RADAR	Radio Detection and Ranging
RCM	Resource Conflict Monitor
RCM	Regional Climate Model
REC	The Regional Environmental Center for Central and Eastern Europe
RGI	Resource Governance Index
ROD	Reporting Obligations Database

RS	Remote Sensing
RUF	Revolutionary United Front
SACs	Special Areas of Conservation
SAR	Synthetic Aperture Radar
SPAs	Special Protection Areas
SPIN	Spatial Indicators for European Nature Conservation
SOE	Status of the Environment
SRTM	Shuttle Radar Topography Mission
SOFA	Status of Force Agreement
TFDD	Transboundary Freshwater Dispute Data Base
UN	United Nations
UNAMIS	United Nations Advanced Mission in Sudan
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCHE	United Nations Conference on the Human Environment
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
GRID	Global Resource Information Database
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space
UNITA	União Nacional para a Independência Total de Angola
UNODC	United Nations Office on Drugs and Crime
UNOOSA	United Nations Office of Outer Space Affairs
UNOSAT	United Nations Operational Satellite Applications Programme
UNSD	United Nations Statistics Division
UNU-EHS	United Nations University – Institute for Environment and Human Security
VHR	Very High Resolution imageries
VMT	Verification and Monitoring Team
WMD	Weapons of Mass Destruction
WCED	World Commission on Environment and Development
WCRP	World Climate Research Programme
WSSD	World Summit on Sustainable Development
WWDR	World Water Development Report

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First of all, we would like to thank all the contributors to this *brief* and participants of the Seminar on 'Environment and Conflict' for their ideas, input, and cooperation. We are indebted to the European Commission's Directorate General Enterprise & Industry for funding the GMOSS Network of Excellence in its Sixth Framework Programme and making the Seminar and this publication possible. We hope that this interdisciplinary initiative will lead to more research and cooperation, as these topics will be more relevant in the future.

In particular, we would like to thank Peter Zeil (Z_GIS) for his continuous support in planning the Seminar, and realizing this publication. We would also like to thank Heike Webb (BICC) for her consistent support in the organization and documentation of the Seminar and Manisha Samal (BICC), who did a tremendous job editing all these texts.

Introduction

Ruth Vollmer[1]

The environment-security nexus is not a new topic in academic and political discourse, but it has currently gained new significance due to a number of factors. Growing concerns about global environmental change including climate change and fears about increasing demand and competition for natural resources caused by population growth and economic development both figure prominently among these factors.

This Introduction briefly touches on some of the issues, which are relevant in this context without discussing them in detail.

Background

Very broadly speaking, one can differentiate between two different aspects of the environment[2]-security complex. The first aspect is that ecosystem integrity is crucial for the sustainability of people's livelihoods. Therefore, certain environmental conditions—often resulting from environmental change, such as qualitative (pollution) or quantitative (depletion) scarcity of ecosystem services—and also natural disasters, can pose an acute threat to security. Such a perspective on security is based on a broadly understood meaning of the term frequently referred to as *human security*, which centers on the individual as the object of security and considers vulnerability as a crucial factor. As there are numerous definitions and approaches to security in this context, they will not be elaborated here; a discussion of security is given in the contribution by Marc von Boemcken, p. 13ff.[3]

Besides this, there have also been attempts to link environment to other security realms. After the end of the Cold War environment has become top of the list of new potential threats to national security.[4] It was linked to international security as it soon became evident that national solutions to environmental problems would not be sustainable in the long run and because of fears about international tensions caused by environmental issues. A very different perspective is taken by approaches, which focus on the security of ecosystems (for an overview see, for example, Matthew, 1996 and 2002).

The second aspect is the question whether there is a relation between environment and conflict. One assumption in this context is that a number of environment-related factors such as environmental degradation or depletion, access to, and management of natural resources can lead or contribute to the outbreak of violent conflict.[5] Such connections have been explored scientifically since the 1980s from various perspectives and with different foci, i.e. international vs. local conflicts. Researchers typically worked on a case-study basis and basically all of them emphasized the role of different structural and other variables beyond the environment.[6] Overviews on how this branch of research evolved and some criticism thereof are provided for example by Dalby, 2008; Matthew et al., 2002 and Fraser, 2002.[7]

However, the two aspects mentioned above are not always clearly separated from each other.[8] The notion of environmental (in-)security is sometimes used to refer to environment-related risks of violent conflict or security implications of environmental change for (northern) states. Furthermore, a human security perspective that centers on the rights and needs of marginal and vulnerable groups and individuals, does not necessarily exclude the possibility of environmentally-induced conflict potentials (Dalby, 2008). Recently, suggestions about potential links between human (in-)security and the risk of armed conflict in the realm of environment have been made by Barnett and Adger (2007).

Central to both of these aspects are the questions: What exactly constitutes the relevant environmental factors? Can they be measured, and if so, how? Recent theories on environment and security/conflict do not see a simple relation between scarcity and insecurity/conflict anymore. One has come to realize that environmental scarcity and its consequences are highly dependent on governance and a broad range of structural factors, which in turn determine the coping capacities, adaptation potentials, and dispute settlement mechanisms of societies.[9] For informed policy-making and sound research, one needs information on both the state of the environment and socio-economic and political data such as details about actual dependence upon environmental services, access rights, adaptation potentials, etc. Concerning the first, satellite-based sensors can provide a lot of the data required via

[1] The author would like to thank Peter Zeil and Marc von Boemcken for their very helpful comments on an earlier draft of this Introduction.

[2] Libiszewski, 1992 gives a definition of environment in this context, which is centered on the ecosystem, which he defines as a "circular feedback control system encompassing the living beings and their biotic and abiotic environment in a certain space" (p. 3). He defines human-induced environmental change as "destabilizing interference in the ecosystem's equilibrium", a process that human beings tend to perceive as degradation (ibid, p. 3–4). The main reason for referring to his definition is that he differentiates between environment and natural (non-renewable) resources, a distinction that is also maintained in this brief and considered analytically important, especially with regard to conflict research (see contributions by Wirkus and Schure, p. 20ff and Krummenacher, p. 43ff).

[3] More details on this aspect of the environment-security nexus can be found for example in Barnett et al., 2008 or Matthew, 2002.

[4] In the academic discourse however, these attempts go back further. Tuchmann Mathews, 1989 and Ullman, 1983 were two of the first protagonists.

[5] This assumption is of course related to a more traditional and militarized concept of security.

[6] See for example Baechler et al., 1996; Homer-Dixon, 1999.

[7] See also contribution by Wirkus and Schure, p. 20ff for details.

[8] See Brauch, 2005 for a discussion of both.

[9] For an example of research on these interactions see Wirkus and Swatuk, 2008.

'remote sensing' or 'earth observation'.[10] The data then needs to be complemented and put in relation with other relevant variables. This is a task, which first requires close and constant cooperation between the people working at the various institutions who can deliver these different types of information. Second, there has to be a broad and scientifically validated consensus on the question, which information and indicators are the relevant ones and how they interact with each other.

A BICC/GMOSS seminar on environment and conflict

This has been the background for this *brief*, which is based on the proceedings of the Seminar 'Environment and Conflict—Evaluating and strengthening the means of interdisciplinary cooperation', which took place in Bonn from the 18–20 September 2007. This Seminar was organized by BICC in cooperation with GMOSS (Global Monitoring for Security and Stability). In the following, there will be a brief introduction of this organizational framework, as it had a major impact on the approach taken and the goals pursued in the Seminar.[11]

GMOSS, an EU-funded Network of Excellence (NoE), was launched in the aeronautics and space priority of the Sixth Framework Programme of the European Union in March 2004. The broader context for GMOSS is a joint initiative by the European Commission and the European Space Agency called GMES (Global Monitoring for Environment and Security). GMES aims at establishing a Europe-wide network for the compilation and analysis of environmental data using both direct and indirect or remote modes of measurement. The specific background for the GMOSS initiative was the perceived need for autonomous European security research. Therefore, the integration of different approaches of European civil security research became one major goal of the network. The 22 GMOSS members are located in 11 different European countries. Most of them focus on earth observation (EO) and some on political science (peace and conflict research). GMOSS was the first NoE that covered the security aspect in the policy framework of GMES. The application of advanced scientific and technological tools has always been at the core of GMOSS and there are mainly five areas of application. These are treaty monitoring, early warning, estimates of static and dynamic populations, monitoring of infrastructure, and borders and damage assessments.

These concrete applications form the central pillar of the GMOSS network and are framed by two other pillars, which focus on supporting the integration of research activities. The first one is the development of generic tools (feature recognition, data integration, visualization, and change detection), the second is about security concepts and comprises scenario analysis, crisis response, and issues and priorities.

The Sixth Framework Programme was the first research funding program set up by the European Union to include the concept of NoEs, that is "multipartner projects aimed at strengthening scientific and technological excellence on a particular research topic by integrating at European level the critical mass of resources and expertise needed to provide European leadership" with the primary aim of "creating a progressive and durable integration of research capacities" (European Commission, 2002, p. 12). Thus, GMOSS members had to develop completely new and concrete mechanisms of cooperation right from the beginning. This meant overcoming fragmentation and competition, which so often hinder fruitful cooperation, exchange, and the creation of synergies as well as developing joint reactions to current developments beyond disciplinary and other borders.

Despite these challenges, GMOSS can certainly be called a success. Over the years, besides delivering a number of products and proposals in very different fields, it has attracted quite a number of additional research institutes who have applied for status as Associate Partners. Of today, there are 11 from six different countries.

The Bonn International Center for Conversion (BICC) applied for Associated Partnership status in October 2006 and was soon granted it.

As the NoE was drawing to an end, this seminar was launched with the perspective of setting the tone for future research in cooperation with GMOSS members and its partners.

The initiative for the seminar was rooted in three different factors:

- Environmental security and questions concerning the conflict relevance of environmental change have featured more significantly than ever before on the political agenda.
- Environmental monitoring has been a classical application area of remote sensing (RS). However, faced with the recent developments and insights on global environmental and climate change, GMOSS has initiated a new discussion on how the application of available RS technologies can be beneficial to this area of research.

[10] "Earth Observation" (EO) is "the commonly used name for satellites that provide images of the earth's surface." "Remote sensing" is "the process of acquiring images of objects on earth from space" according to UNOSAT (see <unosat.web.cern.ch/unosat/glossary.htm>). Both terms stand in opposition to so-called *in-situ* data, which is collected without physical distance from the monitored object.

[11] A much more comprehensive account of GMOSS' goals, tasks, and activities can be found in Zeug, 2007. This presentation of GMOSS activities mostly draws on information given in Zeil, 2007.

- The political science-oriented framework provided by the research BICC and other invited institutions have conducted in this field was hoped to spark initiatives for interdisciplinary cooperation.

The primary goal of the seminar was thus to locate GMOSS thematically in the field of environment and security research. The focus was on (1) the identification of research gaps in this field and (2) the elaboration of options for interdisciplinary cooperation, especially with regard to how opportunities and benefits of remote sensing can be implemented in the framework of the challenges posed by global environmental and climate change. To this end, the Seminar provided a platform for open discussion and exchange between experts from various professional backgrounds. Particular emphasis was placed on the possibility of reacting to and commenting on presentations as well as moving into real interaction and dialogue. This structure is also reflected in the organization of this *brief*. The first three sections consist of a number of contributions that are based on presentations given at the Seminar. The last section attempts to summarize the discussions and to develop suggestions for a future agenda for research and practice. Thus it collects important points and shows where further research is needed and also where and how cooperation is seen to be most important and beneficial.

Content

The contributions in this *brief* take very different approaches to the main topic of monitoring environment and security. Some appear to be merely touching upon it, showing their relevance via their implications for research and practice, while others tackle the central questions directly, presenting however different perspectives on them.

At the beginning of the *brief*, **Marc von Boemcken** addresses the term security as such by discussing two general questions: What is security? What does it do? He then takes a look at how the discoursive link between security and environment has been created and for what reason. **Nils Meyer-Ohlendorf** continues by analyzing how this link is reflected in some security strategies set up by governments and international organizations. Although he focuses on a few select documents, he comes to the general conclusion that while environmental factors are increasingly mentioned, comprehensive policy approaches are symptomatically missing. Continuing on, **Lars Wirkus** and **Jolien Schure** present an overview of research on the role of natural resources and environment in relation to conflicts, followed by a discussion of this relation that focuses on the example of water, presented by **Lars Wirkus** and **Janos Bogardi**. The three subsequent contributions elaborate on the complex issue of security assessments for such uses as early warning and display some of the different approaches to this. **Jeanna Hyde-Hecker** presents a multidisciplinary methodology developed by the Institute for Environmental Security (IES). **Clementine Burnley et al.** evaluate the predictive power of macro-structural indicators on conflict-risk assessments and conclude with a question regarding their usefulness. **Heinz Krummenacher** finally presents the bottom-up approach of the FAST-project conducted by swisspeace. His contribution focuses in a very general manner on the role of environmental factors in violent conflict and concludes that there is basically no causal relation between the two. However, the contribution does not differentiate between environment in general and natural resources or between the different types of resources or between domestic and international events. All other contributions deal with treaty monitoring and thus go one step beyond policy-making. They explore how satellites can actually be used effectively in the implementation and monitoring of international treaties. Two of them concentrate on certain areas covered by international treaties. **Stefan Schneiderbauer** analyzes the opportunities and limits of remote sensing for monitoring humanitarian agreements. In contrast to this, **Peter Zeil et al.** give an overview of monitoring options for environmental agreements. The two final contributions tackle general questions of effectiveness and legal aspects, which **Bhupendra Jasani** illustrates by using the example of conventional arms and aircraft monitoring in Sudan while **Irmgard Niemeyer** identifies the major future challenges in the field of civilian, satellite-based, treaty monitoring.

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1 Approaches to Security, Environment, and Conflict

Security. What Is It? What Does It Do?

Marc von Boemcken

In a world of uncertainty and danger, the desire for security becomes a central concern of political thought and action. Against the threatening forces of unpredictability, rapid transformation, and complexity, it appears to channel a diffuse longing for more reliability, stability, and tangibility. Ironically, however, the very term 'security' itself does not possess an in any way stable or consensual meaning. Rather, it marks the circumferences of a highly contested terrain. For how is security to be achieved? Who is to be secured against which dangers? And, moreover: what actually *happens* when we 'speak security'? To reflect upon any (in)security problem, it would be necessary to, first of all, locate our own position and argument *vis-à-vis* a careful consideration of some basic questions pertaining to the concept and nature of security itself.

For this purpose, I suggest that two broad avenues for thinking about security may be distinguished from each other. The first perspective displays a preference for the question as to what security *is* ('What is security?'). By contrast, the second perspective emphasizes what security *does* ('What does security do?'). In the following, both questions will be addressed respectively. As it will be argued, the two approaches differ considerably in terms of their ontological, epistemological, and normative assumptions. It is, however, not the purpose of this contribution to identify the 'best' way through which security can or should be encountered as an object of analysis. Its objective is, quite simply, to encourage explicit reflection of the term in question, thereby hopefully diminishing the chances for it being applied in an ambiguous or somewhat vague manner.

What is security?

If one sets out to think about security, an obvious starting point might be to ask: What *is* security anyway? Posing such a question is anything but a trivial exercise, for it already makes an implicit assumption about the very nature of security itself: namely, that such a thing as 'security' actually exists. Security, in other words, refers to an actual condition of existence, which is independent of its enunciation in day-to-day discourse. This ontological condition of security has been imagined in quite different ways. For example, in the great debate between Realism and Idealism in International Relations theory, security was either thought of as a relative condition in the present or as an absolute condition of the future. In both cases, however, references to security sought to signify a certain objectivity. This way of thinking has had at least two implications for the way that we ought to go about and study it. First, security is conceived as something that can be objectively known and thus needs to be diligently measured, monitored, and improved by means of reason and scientific inquiry. Second, security attains a normative quality: it appears as a 'good thing' we ought to actively aspire to.

From such a perspective, the general definition of security is usually thought to be encountered in the absence—or at least unlikeliness—of threats to a certain object. For example, David Baldwin (1997) defined security astutely as "a low probability of damage to acquired values" (p. 13). Similarly, for Lawrence Krause and Joseph Nye (1975) it was "the absence of acute threats to the minimal acceptable basic values that a people consider essential to its survival" (p. 330). Such definitions of security seek to somehow capture the underlying *essence* of the term. However, it may yet be conceptualized in quite different ways. In order to move from the essence to the concept of security in the context of a particular academic and/or political project, the most important question to be addressed is: Security for whom? In most cases, the answer would either refer to some or all individuals or to some or all states. It needs to be remembered, however, that security may be equally applied to such diverse objects such as animal life, the biosphere or physical infrastructure.

To further specify the object of security, it may be necessary to not simply point to the actual entity in need of security, but to also identify the endangered *values* that this particular entity contains or represents. For instance, a human being can be associated with several values, all of which may be worth securing. In such case, a concept of security needs to be clear on whether it refers to corporeal integrity, economic welfare, autonomy or psychological well-being. In the end, different objects and values yield rather different conceptualizations of security, the most prominent of which are of course 'human life' and 'state sovereignty'.

Taken by itself, the idea of 'environmental security' is therefore not an accurately specified security concept, for it remains very much open who or what is to be secured. Are we talking about the territorial integrity of a South Pacific island state threatened by climate change and rising sea levels or do we seek to address the decline of individual human well-being and prosperity due to desertification processes? Maybe our object of security is neither the state nor the individual, but the environment itself. But which part of the environment? A certain endangered species or the entire biosphere? Naturally, many of the different security concepts gathered under the umbrella of 'environmental security' are closely related. However, they may also oppose, even conflict with each other. This is aptly illustrated by the brown bear that ravaged through the forests of Bavaria in the Summer of 2007. Identified as a problem ("*Problembär*"), for it threatened the life stock of surrounding farms, the bear was eventually killed. This security measure clearly overrode an alternative conceptualization of security, which would have taken the physical integrity of the animal itself as its principal object. To the extent that different concepts of security may contradict each

other, it is thus of utmost importance that we specify whose security we are actually talking about when taking part in a discussion on security issues.

Once the essence and the concept of security have been clearly delineated, it is in a third step possible to think about the *pursuit* of security. Here, Baldwin (1997) suggested a couple of additional relevant questions. First, and depending upon the particular object of concern, the actual *threats* to security need to be identified. Second, we have to ask ourselves which *means* and *strategies* ought to be employed in order to minimize or even eradicate these threats. Do we revert to coercive military means favoring strategies of surviving and/or deterring danger or do we prefer civilian, for example, developmental means directed against the root causes of threats and thereby associated with strategies of overcoming and transcending danger? Third, we ought to consider how many *resources* should be devoted to increasing security and how the resources spent should be divided among different means and strategies. Finally, Emma Rothschild put forward a further important question, namely: *Who* is going to do the securing? (1995, p. 55) Are state institutions always best suited to provide security? Must state institutions play a dominant role in providing security or can private and/or non-governmental institutions play an equal role in providing security?

Essence of Security	Objective condition described by the absence or low probability of threats to a certain object.
Concept of Security	• Who is to be secured? • Which values are to be secured?
Governance of Security	• What are the threats to security? • By which means and strategies is security to be achieved? • What amount of resources should be devoted to security? • Who is to do the securing?

If we decide to perceive security, including 'environmental security', as both a normative policy goal and a knowable and objective condition of existence, then the procedure outlined above might well serve as a useful guide in order to clearly specify our object of analysis, distinguish it from alternative conceptualizations of security, and conduct research in a coherent and policy-relevant manner. Indeed, I would suggest that the largest part of the debate concerned with the 'redefinition' of security following the end of the Cold War can be traced along the lines of different answers to the above questions. Many critiques of traditional security studies do not therefore contest the ontology of security itself, but rather denote tactical variations within the overriding model of what might be thought of as an 'essentialist' security paradigm.

What does security do?

Although the 'essentialist' perspective is by far the most popular and mainstream approach to the study of security, it is by no means the only way to analytically engage in security issues. Instead of asking, "What is security?" a very different and perhaps a more interesting question is, "What does security do?" Posing such a question does a lot more than simply adopting a slightly different research angle. By departing from the essentialist assumptions of security being a somewhat objective, knowable, and positive thing, it differs profoundly in ontological, epistemological, and normative terms. Security and insecurity are thus not considered as aggregate conditions of existence, which are objectively 'out there' and present themselves to us as unquestionable facts of life. Instead, they are thought of as social constructs by certain actors and for particular purposes. As Barry Buzan, Ole Waever, and Jaap de Wilde (1998) noted in their influential book *Security – A New Framework for Analysis,* security needs to be understood as an inter-subjective social practice (p. 31) that is as something we *do*. In other words, it is "a specific social category that arises out of, and is constituted in, political practice" (ibid, p. 40).

Such a 'constructivist' perspective implies a certain way of approaching and studying security. It would not begin with a laborious effort to identify and define the underlying essential meaning of security, but restrict its analytical scope to the discursive and practical manifestation of the term in social and political life. Security *is*, quite simply, no more or less, than what people say it is. It is a self-referential practice that does not refer to something 'more real' and attains visibility only in deliberate social conduct. In the words of Waever (2000), "(i)t is by labelling something a security issue that it becomes one – not that issues are security issues in themselves and then *afterwards* possibly talked about in terms of security" (p. 8; my emphasis). Notwithstanding the questions outlined in the previous section, we would

therefore have to ask, more fundamentally: *What happens* when certain issues are treated as security issues?

The most well-known response to this question is the so-called 'securitization' theory developed by Buzan, Waever, and de Wilde (1998). By *securitization,* the authors mean a succession of authoritative claims or statements wherein a particular issue (be it military, political, economic, societal or environmental) is successfully presented as an existential threat to a referent object, in turn requiring emergency measures exceeding "the normal bounds of political procedure" by legitimizing the breaking of established norms and rules (ibid, pp. 23–25). As they go on, securitization is, but one albeit, the most extreme form of rendering an issue a problem of governance. In this sense, it may be differentiated from 'politicization', that is, the process by which a problem enters an open public debate, becomes part of a political bargaining process and eventually may or may not receive certain resource allocations (ibid, p. 23). By contrast, if an issue is *securitized* it is presented as so urgent, existential, and important "that it should not be exposed to the normal haggling of politics" (ibid, p. 29). It is lifted *beyond* politics and—by implication—beyond the mechanisms of democratic control and oversight.

Securitization theory is a good example of the analytic shift from 'what security is' to 'what security does'. Importantly, it highlights the profound change in the normative orientation of analysis. Because threats are not self-evident, but always subject to practices of political representation, it is a conscious and deliberate decision whether certain issues should be framed and treated as security issues, namely whether they should be securitized, or not. For Buzan, Waever, and de Wilde, this decision should not be taken light-heartedly. Indeed, to their mind, it is usually better to opt for 'de-securitization', that is to switch out of emergency mode and back into the open deliberations of 'normal' politics.

Obviously, the word 'security' may well be uttered in political discourse without necessarily securitizing a particular issue in the sense outlined above. Especially on the domestic level, in the day-to-day proceedings of internal security governance, security may not securitize as much as it may order social relations in many other ways. Whereas these more mundane 'doings' of security remain largely unexplored, securitization theory is yet a useful, though limited, tool for analyzing the function of security in the international and global realm. A case in point is, of course, the US-led War on Terror, securitizing the issue of terrorism to the extent that it justifies counter-terrorist security measures, which violate human rights and international law. However, securitization strategies may also be encountered in far less obvious places, employed in relation to threats other than military ones, and adopted by actors other than states. For example, it could be argued that Greenpeace goes some way in securitizing environmental issues as existential threats, thereby legitimizing actions outside the normal boundaries of political behavior and in many cases even conflicting with the law.

More generally, it can be concluded that when thinking about the relation between the environment and security, it is important to keep in mind the question as to what security *does*. Here, the strong military connotation, which the term 'security' continues to carry in political discourse, may also be of some relevance for analysis. For to treat environmental problems as security problems could thus either lead to a possible militarization of environmental policy or vice versa, to a demilitarization of the term security itself (cf. Brock, 1992). The discursive effect of conflating environmental and security issues would need to be empirically established from case to case. Finally, it is worth noting that to present an issue as a security problem *always* serves the purpose of instilling that issue with a particular sense of urgency. For this reason, it might well be the case that the discourse of 'environmental security' can be understood first and foremost as a deliberate strategy on behalf of certain actors to elevate environmental issues higher on the political agenda.

Conclusion

This contribution has suggested two very different ways of approaching, thinking about, and analyzing the term 'security', including 'environmental security'. One approach is not necessarily 'better' than the other and the choice depends very much on the specific research question that one sets out to answer. In any case, I hope to have demonstrated that—regardless of the perspective one eventually adopts—there is a clear need to begin a security analysis with some reflection on the meaning of security itself. Such reflection will either serve the purpose of specifying the concept of security that one intends to deploy when assessing an objective security condition. Alternatively, it may also, however, sensitize analysis toward the inter-subjective function of security in political discourse.

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Reconceptualization of Security Strategies and Political Processes

Nils Meyer-Ohlendorf

This contribution discusses in brief whether security strategies integrate environmental aspects and to what extent. Here, pertaining issues will be approached through the cases of the United States, the United Nations, and the European Union.

United States

Driven by the 9/11 terrorist attacks, the 2002 National Security Strategy (White House, 2002) focuses on the War on Terror and emphasizes a narrow military response to the threat of terror by improved homeland defense (creation of a "Homeland Security" department), law enforcement, intelligence, and 'vigorous' efforts to cut off terrorist financing. Although the Strategy focuses on these specific responses towards fighting terrorism, it also touches upon other aspects of security and underlines the security implications of poverty and bad governance. As an additional precondition for security, the Strategy refers to the importance of economic development and environmental protection:

- "[We will promote economic growth through free markets and free trade and integrate environmental concerns into trade policies]. Economic growth should be accompanied by global efforts to stabilize greenhouse gas concentrations associated with this growth, containing them at a level that prevents dangerous human interference with the global climate. Our overall objective is to reduce America's greenhouse gas emissions in relation to the size of our economy by cutting such emissions per unit of economic activity by 18 percent over the next 10 years, by the year 2012. [Our strategies for attaining this goal will be to co-operate with the UNFCCC and make agreements with key industries regarding renewable energies as well as nuclear energy, research and development assistance (although this undertaking will be in the frame of economic policies quite detailed)] (ibid, pp. 19–20)."
- "[In reference to energy security the US will continue to build alliances with partners and friends to fight terrorism. In addressing regional conflicts with partners the US will deliver greater developmental assistance] (ibid, pp. 19–20)."

As an update and revision of the 2002 Strategy, the United States launched a new National Security Strategy in 2006 which predominately rests on two pillars: (1) the promotion of freedom, justice, human dignity, and democracy and (2) international cooperation (White House, 2006). In addition, the 2006 Strategy makes explicit reference to energy security and climate change. It mentions a newly initiated Asia-Pacific Partnership that focuses on clean development and climate change matters as an example for activities, which aim at the enhancement of energy security and clean development. Furthermore, a priority is placed on a comprehensive energy strategy to reduce the reliance of the United States on foreign energy sources. A diversification of energy sources could alleviate the 'petroleum curse' or the tendency for oil revenues to foster corruption and prevent economic growth and political reform in some oil-producing states. However, in the context of energy security, climate change is not mentioned. In this respect, the 'NSS 2006' is less explicit on climate change than the 'NSS 2002'.

Although the US Security Strategies make remarkably detailed reference to the environment and climate change in comparison to other national security strategies, such as of the United Kingdom or South Africa, the Strategies fail to outline concrete measures designed to address environmental aspects of conflict prevention. Accordingly, the Centre for Naval Analysis (CNA) Report on National Security and the Threat of Climate Change recommends that "the national security consequences of climate change should be fully integrated into national security and national defense strategies. The National Security Strategy should directly address the threat of climate change to our national security interests" (CNA Corporation, 2007, p. 7).[1] In addition, it is recommended that the "National Security Strategy and National Defense Strategy should include appropriate guidance to military planners to assess risks to current and future missions caused by projected climate change" (ibid). At the political level, the report recommends that "the U.S. should become a more constructive partner with the international community to help build and execute a plan to prevent destabilizing effects from climate change, including setting targets for long term reductions in greenhouse gas emissions" (ibid).

United Nations

In April 2007, the Security Council held the first ever debate on the impacts of climate change on security. The UK government, which initiated the one-day debate, argued that global warming must be seen as a global security issue as well as an environmental one. It drew support from some governments, but others, including China and leading members of the G-77 group of developing countries, disputed whether the Security Council had the mandate to debate climate change. The discussions referred partly to the security implications of climate change, including adaptation needs. However, they were often only a reiteration of positions, which had previously been expressed already in the context of United Nations Framework Convention for Climate Change (UNFCCC) negotiations.

[1] Under the chairmanship of General Sullivan, 11 retired generals and admirals produced this report, which is available at <http://securityandclimate.cna.org/report/National%20Security%20and%20the%20Threat%20of%20Climate%20Change.pdf>.

In 2004, the United Nations gathered the High-Level Panel on Threats, Challenges and Changes. Its report integrated the threat of 'environmental degradation' to one of the six clusters of threats, but contained very little guidance on how security threats caused by environmental degradation could be adequately addressed. In addition, the 2005 summit reviewing the Millennium Development Goals (MDGs) made no reference to the environment when elaborating on security issues, although MDG 7 is dedicated to environmental sustainability.

At the operational level, the United Nations Development Programme (UNDP) created the Bureau for Crisis Prevention and Recovery (BCPR) for the following reasons:

"To enhance UNDP's efforts for sustainable development, working with partners to reduce the incidence and impact of disasters and violent conflicts, and to establish the solid foundations for peace and recovery from crisis, thereby advancing the UN Millennium Development Goals on poverty reduction."[2]

It is interesting to observe that the main objective of the BCPR is to connect the development work of UNDP to both conflict prevention/recovery and disaster reduction/recovery. Yet, violent conflict and environmental issues do not seem to be considered simultaneously.

The Post-Conflict and Disaster Management Branch (PCDMB) extends the United Nations Environment Programme's (UNEP) work in areas of the world in which on the one hand, the environment is impacted by conflicts and disasters and on the other hand, the environment is a factor in contributing to conflicts and disaster impacts.

PCDMB describes its five core areas of operations as follows:

- Conducting environmental assessments;
- Mitigating environmental risk;
- Strengthening institutions for environmental governance;
- Integrating environmental considerations in reconstruction;
- Strengthening international and regional environmental cooperation.

The PCDMB is one of the most concrete activities of the United Nations on environmental security. The Post-Conflict Environmental Assessment for Sudan provides an example for the PCDMB's work:

"The linkages between conflict and environment in Sudan are twofold. On the one hand, the country's long history of conflict has had significant impacts on its environment. Indirect impacts such as population displacement, lack of governance, conflict-related resource exploitation and underinvestment in sustainable development have bee the most severe consequences to date. On the other hand, environmental issues have been and continue to be contributing causes of conflict. Competition over oil and gas reserves, Nile waters and timber, as well as land use issues related to agricultural land, are important causative factors in the instigation and perpetuation of conflict in Sudan" (UNEP, 2007, p. 8).

Although relatively concrete, the Sudan Assessment also illustrates that the PCDMB's work has not always made specific recommendations on which measures to take when addressing the root environmental causes of the country's numerous conflicts.

European Union

The 2003 European Security Strategy (ESS) does not stress the issue of terrorism, but rather affirms that "in much of the developing world poverty and disease cause untold suffering and give rise to pressing security concerns. Almost 3 billion people, half of the world's population, live on less than 2 Euros a day. 45 million die every year of hunger and malnutrition" (Council of the European Union, 2003, p. 2). Security is understood as being a precondition to development. Nevertheless, the key threats identified next are terrorism, the proliferation of weapons of mass destruction, regional conflicts, state failure and organized crime. The ESS recognizes that "none of the new threats is purely military" (ibid, p. 7), and each needs to be tackled by a mixture of both civilian and military instruments spanning the wide range of both development and security instruments in the framework of EU external action. Even so, the general definition of security remains very broad in the ESS. The strategic objectives (key threats and response) seemingly refer to a narrow and traditional conception of security threats as mainly being human induced.

In addition, the Commission's Communication on Conflict Prevention addresses the relation between conflict/stability and environmental factors. According to this Communication, structural stability is promoted through:

- "Sustainable economic development;
- Democracy and respect of human rights;
- Viable political structures;
- A healthy environment;
- Social conditions;
- The capacity to manage change without resorting to conflict" (European Commission, 2001, p. 10)
- [Addressing the root causes of instability].

[2] *BCPR Mission Statement*. Available at <http://www.undp.org/cpr/disred/english/wedo/wedo.htm>

Furthermore, the Country Strategy Papers (CSPs) play an important role in ensuring a coordinated approach to conflict prevention. In practice this means that when CSPs are prepared, risk factors are systematically checked. For that purpose, the Commission's geographical services are using conflict indicators. Those indicators look at issues such as the balance of political and economic power, the control of the security forces, the ethnic composition of the government for ethnically-divided countries, the potential degradation of environmental resources and so forth.

EU policies on environmental security have evolved over recent years. This evolution includes various 'soft' instruments, such as EU's Aceh policies in addressing illegal logging that has financed the conflict, the EU's work in the Congo in combating illegal trade in gold and diamonds (Kimberley Process), and Palestine, where water projects are under way. However, relevant EU strategies do not foresee a comprehensive and consistent response to the challenges of environmental security. EU policies with implications for environmental security are generally part of development policies and/or specific projects.

Conclusion

Environmental Security has gained importance in the current political discourse. The discussions in the Security Council and some detailed reference to the links between security and the environment give testimony for this development. In general terms, it is recognized in relevant strategies that the environment and security can be interrelated. However, none of the strategies or processes in question provide concrete guidance on how their broad security objectives, which often make reference to the relevance of environmental degradation, can be made operational. There are various reasons for the lack of concrete guidance. Besides the nascent state of the debate, there is a limited understanding in security circles on environmental issues and vice versa. This gap in understanding needs to be bridged through improved communication. A constant and possibly formalized dialogue between security and environment experts could help remedy these shortcomings. Despite its shortcomings and limited success, the EU Cardiff Process on the integration of environmental aspects into other policy areas could provide valuable lessons for an improved integration of environmental issues into security policies. The existing links between environmental degradation and security should provide sufficient stimulus to engage in a fruitful exchange of ideas on how to make objectives of environmental security more operational.

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Environmental Change, Natural Resources and Violent Conflict

Lars Wirkus and Jolien Schure

In the study of environmental security and violent conflict, the availability and role of natural resources can be observed from two distinctive, but strongly interconnected viewpoints:

1. Environmental change induces growing pressure on the availability of natural resources and increases the vulnerability of livelihoods as well as human insecurity.
2. Natural resources, including its exploitation, processing, and export, can be perceived as an economic asset which has the potential to spark or prolong a conflict.

This contribution outlines these two perspectives on 'natural resources' in the context of conflict: respectively 'environmental change and natural degradation in connection with stress and vulnerability' and 'natural resources as the economic asset'. Following this, a few key challenges will be defined.

Linkages between environment, security, and violent conflict

The environment-security-conflict discourse

"The study of environmental security revolves around the central idea that environmental problems—in particular, resource scarcity and environmental degradation—may lead to violent conflict between and among states and societies" (Swatuk, 2006, p. 203). This contention was frequently taken as axiomatic. The ideas have gained momentum since environmental issues emerged on the international political arena in the early 1970s (Gleditsch, 1998, p. 382). The debate was driven by two groups, one group challenging the interlinking of environmental problems with national security studies (e.g. Deudney, 1990; Gleditsch, 1998; Levy, 1995), whilst environment, for the other, cannot be separated from matters of what is called "global security"[1] (Dalby, 2002, p. 95, 2006, p. 175; Worldwatch Institute, 2005).

In the past years mainly three linkages between security and environment were discussed:

- Impact of wars on the environment;
- Impact of military activities in time of peace;
- Environmental problems leading to environmental stress, which could, under certain socio-economic conditions, either cause or contribute to domestic, bilateral, regional or international crisis and conflicts that may involve the use of violence and force.

This contribution focuses on the latter. Since the 1990s, many security researchers and politicians have moved away from narrowly militaristic understandings of threat, vulnerability and response mechanisms, expanding the concept of security to the concept of human security. It is in this context that the issue of the linkages between environmental change and violent conflict became part of the changing security debate. Two interrelated discussions, one on the redefinition of security (Baldwin, 1997; Buzan, 1991; Buzan et al., 1995 and 2003) and the other one, which involved questions about how environmental change threatens global, regional and individual security, (Deudney and Matthew, 1999; Ohlsson, 1999; Renner, 1989) are enriching the various assessments of the nature of the linkages between environment and security.

Renewable resource degradation and violent conflict

The Homer-Dixon led projects on 'Population, Environment and Security' and 'Environmental Change and Security' pursued the linkages between environment, scarcity and violence further by focusing on the causal link between the depletion of renewable resources, such as land, water, forests and fisheries and violent conflict. The Homer-Dixon group identified five types of likely violent conflicts that developing countries will be less able to prevent:

- Disputes arising from local environmental degradation;
- Ethnic clashes or 'group identity' conflicts arising from population migration and deepened social cleavages caused by environmental stress;
- Civil strife caused by environmental scarcity which affects economic productivity and people's livelihoods;
- Scarcity-induced interstate wars, e.g. over water, due to decreasing supplies of physically controllable resources;
- Conflicts between the developed and the developing world over the mitigation of, adaptation to, and compensation for global environmental problems like global warming, ozone depletion, and threats to biodiversity.

The research by Homer-Dixon and his team rested upon scarcity's causal role, which was differentiated in three ways: demand-, supply-, and/or structure-induced as a result of unequal access to and distribution of a resource.

After one decade of research, Homer-Dixon (1999, p. 177) concluded, "that scarcity of renewable resources … can contribute to civil violence, including insurgencies and ethnic clashes" and he predicted that

[1] Dalby (2006, p. 175ff outlines at length in his introduction to Part four of the *geopolitics reader* what is understood as the new 'Global Security'. After the end of the Cold War new global threats, such as climate change, radioactive fallout, ozone layer depletion, or bioterrorism, were understood as threats to people's well-being in the supposedly safe domestic spaces of their lives and communities.

in the future "such violence will probably increase as scarcities of cropland, freshwater, and forests worsen in many parts of the developing world," where the role of scarcity will be "often obscure and indirect." A key finding of his research is that "environmental scarcity is not sufficient, by itself, to cause violence; when it does contribute to violence, research shows, it always interacts with other political, economic, and social factors. Environmental scarcity's causal role can never be separated from these contextual factors, which are often unique to the society in question" (ibid, p. 178).

Maldevelopment, environmental transformation and conflict

The Environment and Conflict Project (ENCOP), co-directed by Baechler and Spillmann started from the premise that environmental transformation does not directly result in conflicts but that it impacts on existing socio-economic conflict potentials, which can violently escalate. By focusing on wealth-driven as well as poverty-driven environmental degradation of natural resources, by putting actors in the center of their research and by concentrating on the key environmental factors of land, soil, rivers, and mining, the ENCOP group examined particularly the contextual links between maldevelopment, environmental transformation and conflict, which have only been marginally touched upon by the Homer-Dixon group. They also took a somewhat longer causal chain into account for their analysis. All conditions, including historical processes and the role of the developed world, which gave rise to environmental degradation, were key.

They paved the way for later governance-oriented research[2] on the interlinkages between conflict and environment by offering a synthesis of environmental degradation, which also shows the potential for a peaceful, cooperative solution of conflicts. "Environmental conflicts become a catalyst for cooperation, if political compromises are seen as desirable and technical solutions feasible" (Baechler, 1998, pp. 37–38).

In the end, most scientists agreed upon the observation that environmental stress acts in combination with other economic and social factors; it was rarely considered to be the sole factor in the precipitation of conflicts.

According to Schwartz (2002, p. 139) there are "five pathways to indirect, internal conflict that involve environmental stress: economic decline, migrations, social fragmentation, erosion of civil society and curtailment of the state."

[2] Such as Conca and Dabelko,1998, 2002; Global Environmental Change and Human Security (GECHS) research project of the Internatial Human Dimensions Program, for more information, see <http://www.gechs.org/>.

Critical environmental security studies

The relationships of environment, security and violent conflict need to be understood in much broader conceptualizations than those included in the narrow empirical studies of the relationship of violence and scarcity in the 1990s. In the past years, it has become clear that the links between violence and environment in cases of conflict over resources are often matters of political struggle over the control of natural resources. De Wilde (2008, p. 599) rightly states that despite its appearance, most environmental security debates are not about threats to nature. He identified "the risk of losing achieved levels of civilization – a return to 'raw anarchy' and forms of societal barbarism – while being able (or having the illusion so) to prevent this" as the main referent object of environmental security. This stems from the fact that environmental change relations to insecurity manifest through conditions of inequality, institutional weakening and impoverishment.

This applies not only in a national or societal context, where struggles between different groups will rise, but also in a geographical context. Global environmental change is bearing unevenly across the world. Some regions will be affected more directly and more severely than others. Following de Wilde (2008, p. 600), "in the short run the long list of environmental problems is more likely to sharpen structural cleavages between haves and have-nots, both on a regional basis and within societies, (…)".

Types of environmental change, which affect human security

The 'Homer-Dixon Group' and the 'ENCOP Group' concluded in their empirical work on environment and conflict that the direct effects of environmental degradation and resource scarcity on the probability of violent conflict are quite weak (Baechler, 1989 and 1990; Homer-Dixon, 1991, 1994, 1998 and 1999) "Violence is by no means the automatic outcome of conflict. (…) Environmental stress plays different roles along the 'conflict dynamic': as structural source; a catalyst; or a trigger" (Lietzmann and Vest, 1999, p. 41). It is increasingly accepted that environmental degradation is at least a contributor to conflict and insecurity. This is also due to the fact that many of today's researchers and politicians are using the wider concept of security—human security—which includes non-conventional threats in their scenarios.

Resource scarcity and environmental degradation are increasingly understood to play an important role in generating or exacerbating conflicts. Talking about environmentally-induced conflict means talking about what types of environmental changes affect human security. Different environmental forces can

be identified, which contribute to such insecurity and conflict:

- Natural disasters, such as earthquakes, volcanic eruptions, floods;
- Slow-onset changes such as deforestation, degradation of arable land, erosion, salinity, siltation, water-logging, desertification;
- Depletion of water resources;
- Overexploitation of fisheries;
- Growing interference in ecosystems from forests to wetlands to coral reefs, which are among the principal processes of human-induced environmental change.

An encouragement for environmental security researchers to work more closely with earth observation specialists is given by Simon Dalby (2008, p. 165), who stated, "In so far as humanity does face a common future, it is one in which global climate disruptions may well cause much more damage to poor peoples than any locally caused environmental disturbances." Global climate change further augments the already aforementioned observable challenges. By reducing access to, and the quality of, natural resources which are important to sustain the livelihoods of people, it will further undermine human security and increase the risk of violent conflicts (Barnett and Adger, 2007). A lot of reports have presented the expected consequences of global climate change as a macro driver of many kinds of environmental changes, such as:

- Rising sea-levels;
- Shifting vegetation zones;
- Dwindling natural habitats;
- Changing precipitation patterns; and
- More frequent and more intense storms, floods, and droughts.

These effects pose a serious threat to human security, especially for the rural poor, because they are likely to undermine the capacity of (often already weak) states to provide the opportunities and services needed by the poor and other local disadvantaged groups to sustain their livelihoods. The more people depend on natural resources or ecosystem services, the greater their vulnerability. Barnett and Agder (2007, p. 641) correctly state, "the way climate change can and does undermine human security varies across the world because the entitlements to natural resources and services vary across space, and social determinants of adaptive capacity are similarly varied."

Resources and conflict: Being cursed or in control?

The link between natural resources (diamonds, gold, cocoa, coltan, timber, and oil) and civil wars has gained increasing attention in the past decade when a proposed link between natural resources and civil wars has become more widely accepted, and studies and reports that were being published on this topic have gained increasing weight. The violent conflicts, for example in Angola, the Democratic Republic of the Congo, and Sierra Leone, were mainly studied in the context of a so-called 'resource curse' paradigm. Only recently have scholars begun to adopt more complex analyses in the study of the presumed 'resource–conflict' dynamic. The following will see a brief outline and highlight some important factors regarding the debate on 'resources and internal conflict' with a special emphasis on the role of resource governance; the key topic of BICC's recently developed 'Resource Conflict Monitor'.

Historical overview

The link between *resource abundance and the onset or duration of civil wars* gained increased attention in the end of the 1990s. Warring parties, which before depended on the support of one of the super powers, now, in post-Cold War times, had to look for new means of sustaining themselves and found high-revenue natural resources, such as timber and diamonds, a viable alternative. Non-governmental organizations (NGOs) exposed this phenomenon, as became illustrated by the issue of 'blood diamonds' that were being traded for weapons by UNITA (*União Nacional para a Independência Total de Angola)* in Angola (Global Witness, 1998; Human Rights Watch, 1999) and the RUF (Revolutionary United Front) in Sierra Leone (Partnership Africa Canada, 2003).

In 2000, the World Bank reported that countries with a higher percentage of natural income from primary commodity exports have been more prone to civil war (Collier and Hoeffler, 2000). This finding very much shaped the public debate and policy-making on the topic and attracted scholars from different academic disciplines to study the resource-civil war phenomenon in more detail. Eventually, the latter brought strong queries on the outcomes of the Collier and Hoeffler study, when efforts to replicate the primary commodity-civil war correlation showed different outcomes. Arguments used to question the study mainly targeted

- The quality of data sets that were used[3], and
- The lack of *specification on the type of resources.*

Many authors argue that different resources have a different impact on civil wars (see Basedau, 2005; Fearon, 2005; Ross, 2004). Important characteristics that

define whether a resource could be a potential factor for conflict are:

- The mode of extraction or assumed 'lootability' of a particular resource (high with artisanally mined resources, low with oil and gas) (Ross, 2004; Snyder and Bhavani, 2005; Fearon, 2005),
- The vulnerability of the resource to price fluctuations and market access that determines the rents (Basedau, 2005),
- The specific location and concentration of resources since they define who has better access to potential revenues (Le Billon, 2001 in Ross, 2004, p. 350), and
- The degree of dependence of resources for a country's economy/ *per capita* income (Basedau, 2005).

The Collier and Hoeffler study, including the many controversial questions raised, kick-started the debate on the link between natural resources and civil war. Much of the discourse on the economic dimensions of civil war now began to concentrate on the question: Are civil wars the result of '*greed*' or '*grievances*'? Collier and Hoeffler's initial work endorses 'greed' as the major cause of civil wars. The 'greed thesis' holds that (measures of) economic motivations and opportunities show more correlation with the start of civil war than (measures of) ethnic, political or religious grievances. 'Grievance' was referred to as (legitimate or not) justice-seeking behavior by rebels. 'Greed scholars' stress that grievances were often unrelated to the objective truth and that in a conflict situation, one could find just about any explanation of grievances that could form the basis of 'the cause' for a conflict. Some scholars raise serious concerns regarding the greed thesis because it builds upon presumed statistical correlation and does not take into consideration that 'individual motivations' can differ and also change over time.[4] Moreover, the greed thesis holds, "The unexplored assumption that rebels- not state actors cause conflict, leading to a pro-state bias in analysis and policy action" (Ballentine and Nitzschke, 2005, p. 4). This labeling of combatant groups as merely criminal organizations instead of possible politically motivated actors also excludes the possibility of considering diplomatic solutions. Furthermore, it is not only the rebels that are the actors, it is also the governments,'*[r]ather, critical governance failures [which] are the mediating variables'* (Ballentine and Nitzschke, 2005, p. 5).

Over the past few years, the analyses of the resource-civil war correlation developed considerably, from treating resource and conflict linkages as a stand-alone issue to a more inclusive approach where "the predatory exploitation of natural resources and the criminal trade in lucrative commodities by armed insurgents and criminal networks" are "visible symptoms of a broader systemic problem" (Ballentine and Nitzschke, 2005, p. 447). "Civil war and resource dependence might as well be independently caused by completely different variables, such as the weak 'rule of law' or property rights" (Ross, 2004, p. 338). Case studies on a number of African countries conducted by Brzoska and Paes (2007, p. 4) illustrate that factors motivating civil wars cannot be simply reduced to resource exploitation. The wars in Sierra Leone, the Democratic Republic of the Congo, and Angola are too often considered as primarily a resource conflict while also in these countries, the link between resources and conflict is far more complex, differs from case to case, and is often difficult to filter out from other factors in the war. By contrast, in some conflicts, such as in Somalia and Côte d'Ivoire, the role of natural resources has mostly been ignored or poorly understood. A more differentiated conflict analysis remains a crucial precondition for effective conflict resolution strategies (Brzoska and Paes, 2007).

The role of the state and governance has been an integral part of the studies on 'natural resources and economic effects' from the 1960s onwards. Corruption and/or mismanagement of natural resources, so-called 'rent seeking' for example is much related to the quality of the state and its institutions (Mehlum et al., 2006). The role of the state and institutions also became an integral topic in the analyses of the so-called 'resource curse' thesis, introduced by Richard Auty in 1993, which offered a further conceptualization of reasons why many resource-rich countries are not able to use the natural resource wealth to boost their economies. The appreciation of the real exchange rate ('Dutch disease')[5], rent seeking, and high price fluctuations are part of the reason. [6] Auty and Gelb (2001, in Auty, 2003) look for further explanations by examining the reverse causation—'the superior performance by resource poor countries' and construct two main reasons: First, states lacking rich natural resources are more successful at developing legitimate political systems that "pursue coherent policies and the aim of raising the welfare of the entire population". Second, resource-poor countries diversify their economies earlier than resource rich countries do and are therefore more competitive in terms of the manufacturing sector (Auty, 2003, pp. 4–5).

In the analysis of the resource-conflict dynamic, experts initially paid great attention to the 'greed vs. grievance' dichotomy as described in the Collier and Hoeffler study. This study placed a predominant focus on illegal resource exploitation and suggested cutting finances of rebel groups. Consequently, the focus

[3] See Fearon and Laitin, 2003, 2005; Basedau, 2005; Ross, 2004.

[4] See Ballentine and Sherman, 2003; Ballentine and Nitzschke, 2005.

[5] This so-called 'Dutch disease', named after the decline of the manufacturing sector in the Netherlands in the 1960s following the discovery of natural gas, creates pressure on the real exchange rate, which in turn, can trigger domestic inflation (Ernst, 2007; Collier, 2007 and 2004; Corden, 1984; Corden and Neary, 1982).

on the resources and conflict link seemed to move governance factors temporarily out of sight. Over the past few years, different studies on the possible resource-conflict links started to focus (again) more on the underlying mechanisms. Important work that goes beyond the 'rebel-greed-hypothesis' has been carried out by Humphreys (2005), who catalogues six possible mechanisms that imply a number of possible underlying factors in the relationship between natural resources and conflict[7]. These additional explanatory frameworks and other recent studies specifically stressed that there should be more consideration of the role of governance (see Dunning, 2005; Snyder and Bhavnani, 2005). "[The] main assumption [is] that natural resources in Africa are more than just a 'curse'. There are complex and dynamic interplays that include numerous non-resource variables, and fairly different outcomes [… A] more cautious label of 'resource politics' seemed more appropriate to us" (Basedau, 2005, p. 325).

Stevens (2003) calls for an analysis of countries that benefit from resource abundance. His findings show that the occurrence of natural resources does not necessarily lead to armed conflict. "Even in Africa, the region with perhaps the highest incidence of armed conflict since the end of the cold war, half of the continent's ten significant producers of alluvial diamonds did not have civil wars during this period" (Snyder and Bhavani, 2005, p. 564). Stevens argues that the focus should be on the mechanism behind the 'curse' and states that "there is a growing consensus that essentially it is something to do with governance" (Stevens, 2003, p. 24).

Concluding this overview of recent studies, the resource-conflict dynamic cannot be simply attributed to the occurrence of natural resources or the dependency of a state on the revenues from these resources. While political and institutional deficits have been widely cited as sources for economic failure and violent conflict, there is still a lack of understanding and empirical study on the impact of governance factors on the resource-conflict dynamic. More efforts are needed to look into broader rather than one-sided explanations and focus more on how governments try to address (or ignore) the problems related to natural resource abundance. In response to this gap BICC initiated the 'Resource Conflict Monitor' study as will be outlined in further detail in the next paragraph.

[6] In addition, prolonged dependence on primary resource exports tends to delay competitive industrialization and slow the absorption of surplus rural labor (cf. Auty, 2007). The effects of the Dutch disease are magnified in fragile developing states characterized by weak state structures, corruption and predatory interests of governing elites.

[7] Gylfason (2001) discusses four channels from abundant natural resources to stunted economic development: a) Dutch disease, b) rent seeking, c) overconfidence, and d) neglect of education.

[8] See Humphreys, 2005, for an explanation on the study of the six mechanisms: 'greedy rebels', 'greedy outsiders', 'grievance mechanism', 'feasibility mechanism', 'weak states mechanism', 'sparse network mechanism'.

The Resource Conflict Monitor (RCM) (see Figure 1), which was initiated by BICC in 2007, builds upon the premise that the issue of resources and conflict has to be seen in the wider context of resource governance. 'Resource governance' describes the way in which governments regulate and manage the use of natural resources as well as the redistribution of costs and revenues deriving from those resources. The Resource Governance Index (RGI), which was developed as one of the integral measures, combines general indicators of good governance (regime type, political rights, civil liberties, press freedom, freedom of assembly and association, and workers' rights) with resource-specific governance indicators (nationally protected land as percentage of total land area, resource regime compliance index, wealth redistribution, and resource independence).

All in all, the RCM combines secondary data (on a total of 198 variables) for 90 low- and middle income countries over an 11-year time period (1996–2007) in order to study how resource-rich countries manage, administer and govern their natural resources and more specifically, to test the impact of the quality of resource governance on the resource-conflict dynamic.

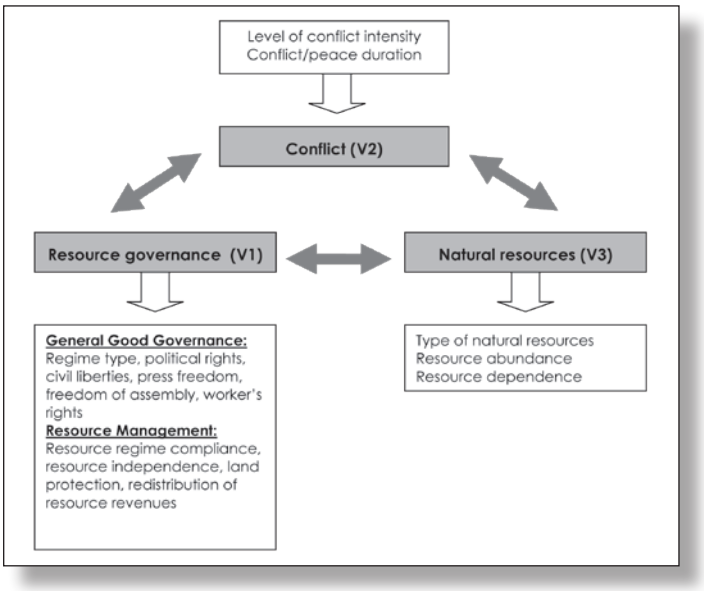
The analyses from the Resource Conflict Monitor study show that the relationship between natural resources and violent conflict is shaped to a large extent by the quality of the governance of those resources, which in turn is a correlate of good governance in general. The analysis confirms that resource abundance as well as resource dependence positively correlates with both the risk and the duration of violent conflict. The risk of violent conflict appears as significantly higher in hydrocarbon-rich countries than in countries rich in other natural resources. Good resource governance indeed diminishes the risk of violent conflict. Moreover, the results confirm the assumption that good (resource) governance increases state stability and, in countries that had experienced violent conflict, the duration of peace (see Figure 2).

Based on the research outcomes, BICC concludes that improving resource governance should be a key focus of development assistance, "Strenghtening good governance in general and good resource governance in particular are concrete measures the international community must take to reverse the resource curse and build sustainable peace and development" (Franke, Hampel-Milagrosa, Schure, 2007, p. 2).

BICC trusts that by constructing the Resource Conflict Monitor it has provided an empirical measure of resource governance that could be of service to organizations and individuals working on this topic. By this means, BICC hopes to contribute to the discussion on new policy options and instruments that can be developed, geared at understanding, perceiving and

acting upon the conflict-relevant aspects of natural resource endowment and to improve and support good resource governance in developing countries.

Figure 1: BICC, Resource Conflict Monitor

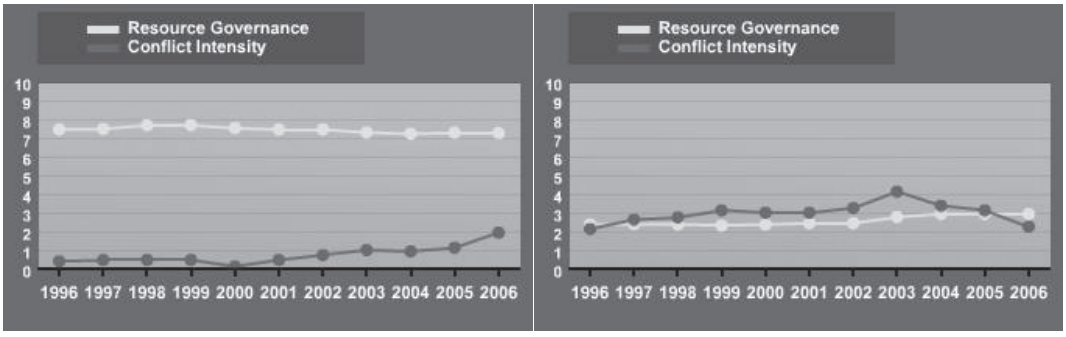


Key challenges

Following the previous two points on the role of resources as either an economic asset or a factor of stress and vulnerability, we can now define a few key challenges. These key points are:

1. **Growth vs. development and reconstruction**. A recurrent question which is being asked is: How can high revenues from resource exploitation be used for sustainable development which enhances stability and reconstruction of former conflict areas? It is likely that commodity prices will drop again at one stage. At the same time, pressure on resources is increasingly due to population growth in developing countries and new booming economies.
2. **Resource governance, but no blueprint.** Resource governance and global policy solutions should take into account that context-specific factors (and past experience) make 'blueprints' a less favorable solution.
3. **Poor international solutions/ more conducive markets.** The range of non-military options, which can influence the behavior of external economic actors and international rules and regulations, such as UN Sanctions, the Extractive Industries Transparency Initiative, the Kimberley Process, the OECD Guidelines for Multinational Companies, the Voluntary Principles on Security and Human Rights, the ILO conventions, and the Equator Principles for private banks has increased significantly in the last few years. However, an effective mechanism, which ensures that resource exploitation contributes to sustainable peace and development is missing. How can current regime laws and standards be broadened and international markets become conducive and inclusive to a just distribution of identities, power, and resources?
4. **Monitoring, new technologies, GMOSS.** How can new technologies assist in monitoring the risk factors which exist in the resource sector? Who will have access to this information and what does this mean in terms of power relations and effective use?

Figure 2: Resource Governance Index



www.Resource-Conflict-Monitor.org provides free access to the Resource Governance Index for 90 low- and middle- income countries over the past decade. Visitors to the website can directly see a graph and enter the data for country-specific resource governance trends and how this may correspond with a change of conflict intensity and the resources available. Also, there is an overview of the three country groups sorted according to their respective scoring on the Resource Governance Index (high, medium or low).

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The Global Water Crisis—Are Water-related Violent Conflicts Becoming More Likely?

Lars Wirkus and Janos Bogardi

Introduction

> *Water gives life to everything, including human development and human freedom*
> (Human Development Report, 2006, p. 2).

Water covers 71 percent of the earth's surface. However, only 2.5 percent of the water, which can be found on our planet, is freshwater. Two-thirds of that amount is bound in glaciers and permanent snow, thus non-usable for human demand. Albeit the remaining useable small fraction of the world's renewable freshwater has—in absolute terms—up to now been more than sufficient to sustain humankind. Nonetheless, at the same time water is increasingly becoming a scarce resource in many parts of the world. According to Saleth and Dinar (2004), global freshwater withdrawals dramatically increased during the last century from 500 to about 4,000 cubic kilometers per year. "Although current withdrawal represents no more than five percent of the physically accessible global fresh water resources, it is close to a third of the planet's economically accessible blue water resources" (ibid, p. 4). The United Nations Development Programme (UNDP) highlights in its 2006 Human Development Report (HDR) that still today some 1.1 billion people in developing countries have inadequate access to freshwater resources (HDR, 2006, p. 2). Trusting in current trends of the development of human society on a global scale, water scarcity most likely will become a more pressing threat to humankind in the near future. At present the water consumption on a global scale doubles every twenty years. According to the United Nation's World Water Development Report (WWDR), almost two billion people are affected at least by temporary water shortages in over forty countries today (WWDR, 2003, p. 10). Linked to population growth and changed production and consumption patterns, water withdrawals have increased drastically in the past centuries. This already has brought different users and uses into contact and competition, or should we better say conflict, with each other. Boege (2006) rightly assumed that in view of population growth and increase in water use due to agricultural development, industrialization, urbanization and *per capita* use increases due to changes in lifestyles, the situation is bound to worsen in the coming decades. Following UN assumptions, seven billion people in sixty countries will suffer from water scarcity by the year 2050 in the worst case, and "even under the lowest projection, just under 2 billion people in forty-eight countries will struggle against water scarcity in 2050" (WWDR, 2003, p. 13). Hence the UN World Water Development Report concludes that the world is facing a dramatic and escalating water crisis. It "is holding back human progress, consigning large segments of humanity to lives of poverty, vulnerability and insecurity. This crisis claims more lives through disease than any war claims through guns" (HDR, 2006, p. 1). Especially in several arid and semi-arid regions of the South, including parts of the Middle East, Central Asia, the Indian subcontinent, and particularly Africa, water scarcity today has reached alarming dimensions.

Addressing water scarcity one also has to bear in mind that "water is needed to meet not only human needs but also the needs of the water-based ecosystems that form part of the global life-supporting system" (Saleth and Dinar, 2004, p. 4). Global environmental change, e.g. climate change and its projected consequences, as well as regional and local problems caused by the environmental degradation of freshwater resources not only contribute to, but even aggravate this scarcity. Large parts of the global water crisis, and particularly the majority of regional and local water problems, are due to weak or even bad water governance. In such cases the political parameters, institutions, and mechanisms required to ensure that water resources are used sustainably are in need of optimization (Wirkus and Boege, 2006, p. 15). Summing up this phenomenon, the authors of the HDR 2006 rightly state that "the scarcity at the heart of the global water crisis is rooted in power, poverty and inequality, not in the physical availability" (HDR, 2006, p. 2) and that it is "manufactured through political processes and institutions that disadvantages the poor" (HDR, 2006, p. 3). Nonetheless, in large parts of the world the availability of water is a crucial issue. Arguing on a global scale, as the authors of HDR 2006 did, is misleading as it obscures the fact that a sufficient amount of water on a global scale does not solve problems of people in semi-arid and arid regions on the local level who are suffering from having no access to water. As described above, in many parts of the world there is enough freshwater available for domestic purposes, for agriculture and industry, especially if available water-saving technologies and practices were implemented. The problem is that large parts of the world's population are excluded from access to water resources, not only through physical unavailability, but also through marginalization, limited access rights, or by public policies, which set false priorities for access to water-providing infrastructures.

Water and conflict

Anthropogenic water scarcity, which is particularly felt in arid regions where water is naturally scarce, may lead to (violent) conflict over water especially in situations of weak or bad (water) governance. Not only that water is becoming a scarce resource, it is also divided extremely unevenly between regions and states as well as between societal groups. "Unevenly divided scarce resources are—as empirical evidence throughout history shows—contentious subjects of conflict" (Boege, 2006, p. 4). Under these conditions, states, subnational social groups, and households are

more likely to compete over access to and distribution of water. "In other words: Man-made water scarcity is conflict-prone" (Boege, 2006, p. 4).

As to its relevance for conflict, water is a special resource compared to other natural resources. Without a considerable economic value on the global market and at the same time being a commodity, which is not easily tradable, water, although a precondition for human and economic development, does not serve to the same degree as a basis for economic power and political might as for instance oil, diamonds, or timber do. Furthermore "water and the revenues derived from its exploitation neither lend themselves to the stabilization of authoritarian regimes nor to secessionist causes. Water is not a lootable and tradable commodity that might drive and sustain war economies" (Boege, 2006, p. 12). Besides the already mentioned issues of scarcity (in the sense of accessibility and availability), the renewable resource water, in contrast to non-renewable natural resources, such as oil, diamonds or copper, can be subject to environmental degradation, which in turn can be a cause of (violent) conflict. Often, this environmental degradation of renewable resources, such as water, land, forests, wildlife and air, takes place in the process of the extraction and exploitation of non-renewable resources. The negative consequences of this degradation are hazarded, which in the worst case can lead to massive (violent) conflict between different user groups as the affected local population heavily depends on clean, useable and safe water resources.

Environmental degradation-related (local) conflicts can easily cause international tensions, since many rivers, lakes, groundwater reservoirs, marshes and wetlands are shared across international boundaries. It is a well-known fact that nature does not respect man-made political borders. By its ultimate fugitive character—it fluctuates in both time and space—water links various users across borders in a system of hydrological interdependence. On a global scale, this holds especially true for an unknown number of aquifers and the 263 rivers which are shared by two or more sovereign states. There are two different kinds of constellations in which a river can be shared: first, states can be neighbors which have a common boundary river; second, the river flows through one state first, and later through another. These two cases make for two very different situations, two different settings of interwoven development and security interests. While in the first case, states may more easily perceive the river management as a common mission, the second case represents a classical upstream-downstream constellation with a clearly marked power divide with a probability of competition for water, rather than its joint exploitation coming to the fore (Boege, 2006). All in all, water as a resource that traverses both nature and society has multiple and conflicting demands on its use—ecological functioning, food production, economic activities, health and recreation, just to name a few. Conflicts may arise if water is—or is perceived as being—(over-)used and/or degraded by other actors at a cost to oneself. The possibility of conflicts at international, regional and local level regarding access to and use of freshwater therefore poses a serious threat to both human security and the security of states. To make the situation even worse, international law that governs water is poorly developed, often contradictory and unenforceable. Following Wolf (2006) it is "no wonder that water is perpetually suspect—not only as a cause of historic armed conflict, but as the resource that will bring combatants to the battlefield in the 21st century."

The myth of 'water wars'

In the arid and semi-arid regions of the South where water is crucial for economic development and societal well-being and is scarce at the same time, conflicts between upstream and downstream or bordering riparians have already led to serious tensions. Convinced of the assumption that, should "competition for water intensif(y) within countries, the resulting pressures might spill across national borders" (HDR, 2006, p. 19), the myth of upcoming international or regional 'water wars' solidified in politics and research for a long time. Hence the discourse on water and violence, focusing on the 'water wars' hypothesis only, exemplified again and again by the same rivers, e.g. the Nile River, the Euphrates and Tigris, the Jordan River, and the Amu-Darja and Syr-Darja, has lead to a highly distorted picture. Over the last decade or so a huge amount of studies were published either favoring or challenging the 'water war' thesis (Du Plessis, 2000; Gleick, 1993, 1994a, 1994b; Homer-Dixon, 1999; Klare, 2001; Wolf, 1999a, 1999b, 2002a, 2002b; Wolf at al., 2002, 2003). A host of case studies addressing individual international river basins as well as comprehensive overviews have been elaborated. The results of this thorough empirical research reveal that so far no serious conflict has arisen with regard to the large majority of transboundary river systems, and even in many of the most conflict-prone cases the outbreak of large-scale violent conflict has been avoided. Two of these important research initiatives and their results will be briefly described below.

From Potential Conflict to Cooperation Potential (PCCP)[1]

Munter Haddadin, former Minister of Water Affairs of the Hashamite Kingdom of Jordan expressed it very pointedly, "water extinguishes fire, it does not ignite it".[2] This could have been the slogan of the project 'From

[1] <http://www.unesco.org/water/wwap/pccp/>.

[2] At the 1st UNESCO/PCCP conference, 20–22 November 2002, Delft, The Netherlands

Potential Conflict to Cooperation Potential' (PCCP) launched by UNESCO in 2000. The first phase of this project, which was presented at the 3rd World Water Forum in Kyoto in 2003 focused on the potential conflicts (and cooperation potential) between sovereign states. This comprehensive project, which in its first phase produced almost 30 reports, has shown in a dozen of river basin case studies, including some of the most contested ones like the Nile, in a series of thought-provoking 'think pieces' about historical comparisons, in reports about negotiations and the use of systems analytical (modeling) methods in river basin management and in the proceedings of a comprehensive symposium that water, at least on the scale of international/ transboundary resource management was, and is an agent of cooperation, rather than of conflict. No evidence of 'water war' could be found in four millennia of human history. Having constated this, the conflict potential, if grievances remain unaddressed can not be denied. It was expected that on smaller scales in competition over a scarce resource among the same type of users (like pastoralists or subsistence farmers) or different users of the same resource (like irrigation versus hydropower, or rural versus urban users) conflicts, even violent ones, would erupt. Unfortunately, after 2003 the PCCP project deviated from the original concept and did not enter into its originally conceived second phase to address these types of conflicts. The currently running MICROCON[3] project will illustrate these 'micro level' water conflicts. However, its broader focus on various resource conflicts implies that MICROCON cannot be claimed to be the continuation of the original PCCP concept.

Basins at Risk (BAR)

The most comprehensive empirical work on the issue of international water courses and conflict, the so-called Basins at Risk (BAR) project at Oregon State University and its Transboundary Freshwater Dispute Data Base (TFDD) (Wolf, 1999a) have put the 'water wars' thesis into perspective. Aaron T. Wolf and his colleagues assessed all reported events of either conflict or cooperation over water resources between two or more states in the period from 1948 to 2000. They found that of the 1831 interactions between riparians the vast majority (1228) was of a cooperative nature. They also found that, over the last fifty years, approximately 200 treaties about the common use of shared water courses were put into effect. 507 conflictive events were registered. In only 37 of these violence was used and only 21 included military action. And of these 21 cases (out of 1831), 18 involved Israel and its neighbors, hence pointing to a very specific conflict constellation. In fact, not one single 'water war' can be found in the data base[4] (cf. Wolf et al., 2003).

What this research has also shown is that the absence of transboundary institutional mechanisms can lead to disruptive conflicts. Quite often this kind of tension is expressed by official verbal hostility or diplomatic hostile acts such as the 'famous' unveiled threat of the former Egyptian President Anwar Sadat in 1979, who stated, "(t)he only matter that could take Egypt to war again is water" which was directed against Ethiopia, the upstream neighbor that controls 85 percent of Egypt's lifeline, the Nile River. In 1990, Jordan's King Hussein issued similar warlike declarations. These two examples also prove that hydrologic needs of riparian countries are often intermingled with political considerations. In the end, politics decide on a peaceful or violent course between states.

In the context of these positive developments on the international level, clinging to a deterministic view which assumes that there is a direct causal link between water scarcity and large-scale violent conflict would go in the wrong direction. However, water scarcity and the degradation of transboundary water resources obviously does not automatically lead to violent conflict between riparians. Quite contrary to the water war assumption, the dependence on transboundary water courses offers strong incentives for cooperation. "Many conflicts over the allocation of water use rights continue around the world but most of them are within states and international disputes simply do not have a history of leading to wars" (Dalby, 2008). The pitfalls of violent conflict, which might simultaneously harm basin riparians to the same degree are much greater than any possible benefits of going to war. Even though international law which governs water is poorly developed, often contradictory or unenforceable due to its non-binding character, hundreds of bilateral and multilateral agreements—already in place—dealing with specific concerns regarding international freshwater resources underline Dalby's observation. Many of these agreements were inspired by the UN Convention on the Law of the Non-navigable Uses of International Watercourses (21 May 1997) as an example, which provides a general framework of basic principles for the use of international rivers by riparians.[5]

Addressing local water conflicts

As pointed out above, the 'water wars' discourse has been the leading paradigm for years, concentrating energy and resources on the international level. BAR/ TFDD and all other 'water war'-related research so far has been confined to the macro level. By doing so, science as well as politics have omitted the subnational level. "Given the fact that internal violent conflicts constitute

[3] MICROCON stands for Micro Level Analysis of Violent Conflicts; see <www.microconflict.eu>.

[4] See <http://www.transboundarywaters.orst.edu/projects/bar>.

[5] The UN Watercourse Convention was adopted with 103 states voting in favour, 27 abstentions and three against, namely Turkey, Burundi and the People's Republic of China (which all are upstream riparians).

the bulk of today's wars", this is according to Boege "a shortcoming of major importance. Maybe water played a role in internal violent conflicts on a much larger scale than in the international arena" (Boege, 2006, p. 6). No comparable research efforts have been geared to the local level so far.

At present, the dominating opinion in the research community is that climate change, population growth and environmental degradation will accelerate the water cycle. Overuse and the degradation of water resources could therefore become a source of violence-prone or even violent conflict not in the international realm, but in the sub-national or local context (which does not exclude transnational repercussions) (Boege, 2006; Gleditsch et al., 2005; Ohlsson, 1995, 1999; Ravnborg, 2004; Swedish Water House, 2005; Turton, 2004, 2005; Wirkus, 2005). Besides the assumption that more competition for water leads to the local poor losing their access to water, which consequently limits their options for moving out of poverty further, there is the apprehension that increased competition for water leads to more conflict among users within as well as among different sectors.

The most advanced research in this field poses that water-related violence in the future will not take the form of 'water wars' across national boundaries, but of localized water point clashes between immediate water users, and of 'water riots'. To give only two examples: In situations of scarcity (droughts in particular) conflicts are carried out between immediate water users who are highly dependent on the resource, especially if different social groups, such as nomadic pastoralists and sedentary farmers and irrigators, use water for different purposes. This, however, does not mean that there is no danger of violent conflicts between different groups of pastoralists. The ongoing Borana-Gabra conflict serves as one example for that kind of subnational localized water-related violence, which has lead to clashes, raids and massacers in the Marsabit District of northern Kenya close to the Ethiopian border. Competition over water (and grazing land) in this semi-arid region between pastoralist communities from the ethnic groups of the Borana and the Gabra turned violent. Hundreds of people were killed and thousands displaced. The underlying causes of the violence are long-running disputes over water and pasture. The fact that the Borana and Gabra reside on both sides of the Kenyan-Ethiopian border complicates the conflict further. It is at the same time a local and a transnational conflict. Migration caused by the (forced) resettlement of people affected by water-related infrastructure construction—large dams in particular—may also contribute to violent conflict, either between state authorities and local people who resist resettlement or between the resettled local groups and receiving local communities who are hostile to the newcomers, especially if in-migration increases pressure on already scarce resources. A case in point in this context are the experiences that were made in the context of the Lesotho Highlands Water Project (LHWP) with its resettlement component.

However, so far only very limited research with regard to these localized forms of water-related violence has been conducted. The perception of growing local water conflicts is based mostly on sporadic accounts of local clashes rather than on systematic empirical evidence. Even less is known about how local communities and individuals fare in such local conflict and cooperation, and, in general, how they are affected by increasing competition for water. The role of local governance with regard to a violent or non-violent conduct of conflict also needs to be examined.

Fortunately, two promising research projects started independently of each other in 2007 to gain more knowledge about the micro level and localized water-related violent conflicts as well as cooperation on the local level:

- The UNU-EHS[6] research on Water Management and Violent Conflicts within the EU-funded research program MICROCON. Its objectives are to analyze the structural causes and the motivations of actors that lead to violent or non-violent conduct of water-related conflicts and cooperation in the local water point context, and
- The research program on Conflict and Cooperation in Local Water Governance, funded by the Danish Institute for International Studies. Its objective is to contribute to sustainable local water governance in support of the rural poor and otherwise disadvantaged groups in developing countries by improving the knowledge among researchers and practitioners of the nature, extent and intensity of local water conflict and cooperation and their social, economic and political impacts, and how this may change with increased competition for water.

Earth observation, water and conflict prevention

In the above-described context, remote sensing can play various roles. Besides the obvious option for serving as a tool to collect, generate and share information about the catchment area and/or the transboundary water resources (rivers, lakes and groundwater) themselves other roles for earth observation technologies are conceivable. On the one hand one could think about using remote sensing to monitor existing multilateral agreements on transboundary water resources management (e.g. infrastructure projects). By doing so, it could contribute to and strengthen the efforts

[6] United Nations University – Institute for Environment and Human Security

of confidence-building measures of transboundary water institutions. It also can help in the context of environmental security assessments, the mapping and analysis of ongoing local conflicts as well as conflict prevention. Based on a set of measurable indicators, existing early warning systems could be expanded to include local and national water conflicts.

Remote sensing permits quickly available large-scale information on the state of the resource. Knowledge or rather the lack of it can always be identified as the source of suspicion, mistrust, and the breeding ground of conflicts. Remote sensing overtops the man-made limitations on transparency of water resources data. Serving as basis for information systems, remotely sensed data is an important prerequisite and tool for conflict prevention, resolution, negotiation, and ultimately cooperation.

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2 Environmental Security- and Conflict Risk Assessments

Environmental Security Assessments: The IES Method

Jeanna Hyde Hecker

The Institute for Environmental Security (IES) is an international non-profit non-governmental think tank established in 2002 in The Hague, The Netherlands, with liaison offices in Brussels, London, and Washington, DC.

The Institute's mission is "to advance global environmental security by promoting the maintenance of the regenerative capacity of life-supporting eco-systems."[1]

The mission and programs should be seen in the context of promoting international sustainable development goals and as a contribution toward long-term poverty alleviation as advocated in:

- Agenda 21;
- UN Framework Convention on Climate Change and Kyoto Protocol;
- Millennium Development Goals;
- Plan of Implementation of the World Summit on Sustainable Development;
- Monterey Summit on Financing for Development; and
- Doha Development Agenda.

Additionally, the Institute's perspective on environmental security refers to the availability and quality of environmental services for humans and nature. Alterations such as, deforestation, reforestation, mining, disturbance of vulnerable ecosystems, etc., in the availability and quality of these services, can have a significant impact on environmental security. Thus, the environment plays an important role with regard to conflict creation, prevention, escalation, regulation and mitigation. For instance, environmental destruction may lead to resource scarcity and scarcity may trigger conflict, which in turn may escalate into violence. Nevertheless, the availability of abundant natural resources can also cause conflict or violence. Violence can cause further destruction therefore leading the environment and human health to spiral downwards. This all becomes a vicious cycle. Moreover, the cycle can have different starting points as well, for instance, conflict or violence triggered by reasons other than resource scarcity or abundance. This in turn could all lead to environmental destruction.

The IES utilizes a multidisciplinary approach, which integrates the fields of science, diplomacy, law, finance, and education.

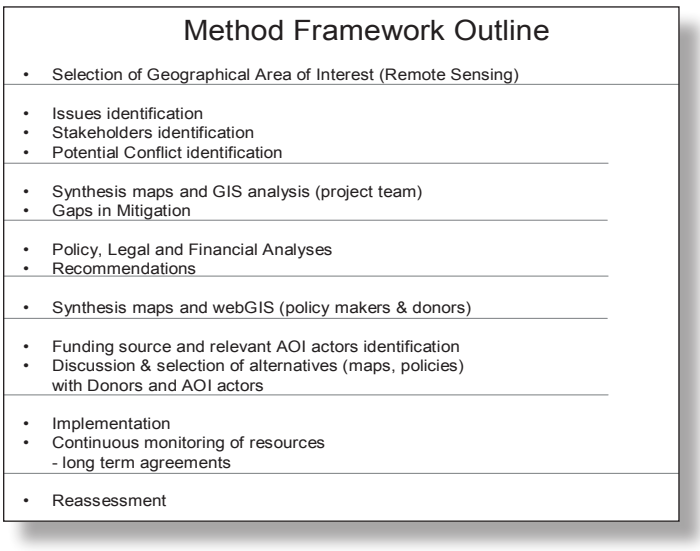
Key objectives of the multidisciplinary approach are:

- **Science**: Create enhanced decision tools (using remote sensing, (web)GIS, cartography, natural resource management, and decision tools) for foreign policy makers, donors, and their target groups on regional, national, and local levels
- **Diplomacy**: Promote effective linkages between environment, security, and sustainable development policies.[2]
- **Law**: Contribute to the development of a more effective system of international law and governance.[3]
- **Finance**: Introduce new and innovative financial mechanisms for the maintenance of the globe's life supporting ecosystem.[4]
- **Education**: Build the environmental knowledge capital of people and organizations.[5]

The IES is currently running a five-year program called "Environmental Security for Poverty Alleviation" (ESPA), which is executed by means of the Environmental Security Assessment methodology. The methodology is built up from experiences in the four case study areas of Central Kalimantan, Indonesia; Matavén Forest, Colombia; Democratic Republic of the Congo and Virunga Bwindi, Great Lakes region, Africa.

The method being used, as common practice, retains the five disciplinary areas to ensure that assessments are as comprehensive as possible. The framework of the method can be seen in Figure 1.

Figure 1: Institute for Environmental Security EnviroSecurity Assessment Method Framework



[1] "IES Mission". Available at <http.//www.envirosecurity.org/about/>.

[2] See: Greening European Security Initiative <http://www.envirosecurity.org/ges/>.

[3] See: Pathfinder Project on Combating Illegal Trade in Natural Resources <http://www.envirosecurity.org/activities/law/trade/>.

[4] See: Eco-Insurance for a Sustainable Future <http://www.envirosecurity.org/activities/finance/>.

[5] See: Planet2025.tv <http://www.envirosecurity.org/activities/education/planet2025tv/>.

ESPA intermediate and end products are the Environmental Security Assessment reports, which include background information on the study areas from ecological, social, and political perspectives, descriptions of issues, and causal relationships among them, and a list of recommendations and alternatives, a legal analysis of the major issues, an interactive mapping interface, and posters. The IES also utilizes the findings in its yearly briefings to various audiences whether potential donors, stakeholder or support groups.[6]

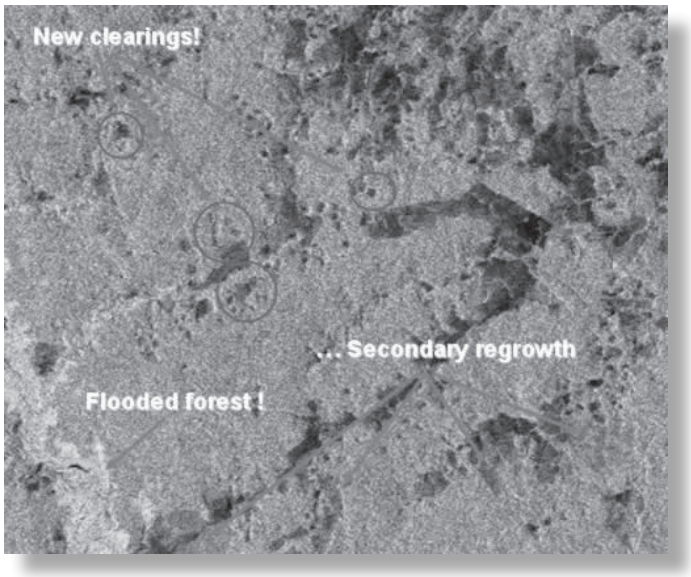
Environmental security assessment method applied to Matavén, Colombia

Colombia is the world's third most megadiverse[7] country. It encompasses part of the Amazon and the IES study area falls on the northernmost part of the Colombian Amazon. The study area has been selected because it is rich in biodiversity, endemism, and has rare ecosystems. There are indigenous people who inhabit this region and utilize and preserve the ecosystems in a sustainable manner. The indigenous people live on a strip of land that encircles the Matavén Forest. The inner forest is called the Heart of Health (*Corazon de la Salud*) because they believe that as long as they take care of the forest and the resources within it, their communities will continue to thrive for generations. The wealth of natural resources and little infrastructure in the region are conditions sought out by insurgent groups. These groups are interested in, among other things, the planting of coca and production of cocaine. History has shown that once insurgents move into an area for coca production, there is conflict over land. They force the locals to grow coca and produce cocaine. If the locals resist, they are killed or driven off their land. In addition, many flee before violence ensues. In Colombia, between 2000 and 2005, there were 1.6 million internally displaced persons (IDPs) who had to leave their municipalities because of violence (UNODC, 2006). When IDPs settle in a new place, tension and clashes often break out between them and the original residents. They are also unable to carry on their traditional way of life either because the new environment is too different or because the new society does not allow it. Poverty or resorting to illegal activities such as planting coca is often the result. In addition, if they are able to adapt to the new environment, then they usually risk losing their traditions.

As a consequence of preparing coca for cultivation, there is deforestation, soil erosion, and water sedimentation. Additionally, many chemicals are used on the coca crops, such as fertilizers, pesticides or fumigation. All these toxic substances end up in the rivers where they affect the health of people, animals, and plants; finally impacting on the diversity of Colombia as well as neighboring countries.

Remote sensing can be used to evaluate natural resources and monitor indigenous territories for early signs of forest exploitation (Figure 2). The indigenous people of Matavén are aware of the encroaching coca front, but it is not always easy for them to patrol their own territory. Coca growers have chased away and threatened indigenous people from areas where indigenous territory and coca fields coincide (Figure 3). Also, some parts of the Matavén forest are considered sacred by some indigenous groups and are therefore unexplored. With remote sensing, the invasion of 'unexplored' areas as well those occupied by indigenous people can be monitored. Such monitoring can thus serve as an alternative to regular visits to these areas.

Figure 2: ALOS PALSAR radar image 2006 showing land cover in area adjacent to the Matavén Forest.



Source: SarVision.

[6] All these products can be found online at <http://www.envirosecurity.org/espa/>.

[7] A country that harbors the majority of the earth's species and is therefore considered extremely biodiverse.

Figure 3: Map showing boundary of Matavén Forest, Colombia, adjacent to coca fields (diagonally striped patches).

Strengthening indigenous rights and the indigenous people's ability to govern are also keys to maintaining the environment and preventing conflict. They must be aware of the consequences of commercial activities and sustainable alternatives. They must also know what authority they have and how they can protect their territory.

Compensation for ecosystem services may help the local people to prevent or curtail conflicts. Rather than surviving on coca production, locals can benefit from compensation mechanisms set up to protect ecosystems for instance, with the aid of remote sensing as well as to provide means of sustainable livelihood and empowerment for their self-governance. With such alternatives, locals are not forced to utilize their land for potentially unsustainable ventures such as the exploration and extraction of oil and other minerals, logging, and cattle ranching.

The IES has played a leading role in the development of the Guiana Shield Initiative (GSI) Phase II project. The Guiana Shield is a geologic formation of sandstone outcrops, which determines the ecology of 250 million hectares across six countries—Brazil, Colombia, Venezuela, Guyana, Surinam, and French Guyana. The eco-region is comprised of large, intact, pristine forests, and watersheds. Thus, important ecosystem services are biodiversity, hydrology, and carbon sequestration. The project aims at promoting sustainable development and integrating eco-regional management for the six countries. The region is targeted as a good place to build and test financial mechanisms for ecosystem services while providing benefits to the local communities involved because of the ecological value, the threats from commercial activities for minerals, timber, and other non-sustainable land use, and the local interest to conserve.

The IES case study site in Colombia, the Matavén Forest, is one of the GSI pilot sites. In each pilot site, there will be testing of financial mechanisms or compensation for forest management, policy development, and support for small businesses and communities while exploitation of resources will be addressed. Agreements will be made between community organizations and, for instance, donors, to prevent environmental destruction and conflict. These agreements and land use change will be monitored by means of remote sensing technology.

On a larger, more global scale, however, the Institute promotes the investigation and testing of continuous remote sensing monitoring of potential hot spot areas. It also promotes the mainstreaming of (spatial) information technology into decision-making on natural resource management and sustainable development. This could be facilitated by forging partnerships and sharing agreements amongst data providers and users. Such collaborations would benefit providers who need to justify their efforts, myriads of users with more informed decision making, and environmental security, as more sustainable choices could be identified.

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UNODC. See: United Nations Office on Drugs and Crime.

Quantifying the Risk of Armed Conflict at Country Level—A Way Forward

Clementine Burnley, Dirk Buda and François Kayitakire

Introduction

In the field of conflict studies, automated data processing for relevant information extraction is essential to process the huge amounts of data being collected on countries and political groups. Automated quantitative information analysis can support political decision-makers to make timely evaluations of the risk of severe crises. Such tools are more and more required in the framework of early warning systems. This contribution aims to provide a scientifically sound approach to build a statistical model to assess quantitatively the risk of intra-state armed conflict on the global level. Particular attention is paid to the operationalization of the approach in early situation assessment.

Quantitative methods applied to conflict risk assessment can be classified into two categories according to the type of independent variables (structural indicators versus past conflict events) used to predict or estimate the risk. Risk assessment seeks to assess the probability of future instability on the basis of estimable relationships between structural risk factors, while early warning seeks to flag emerging crises as early as possible by monitoring recognizable patterns.

This contribution concentrates on the risk assessment. It is worth noting that the concept of *risk* should also include an estimation of the conflict impact, an issue that is not dealt with in the present study. For the sake of brevity the term *risk* is however used instead of the probability of occurrence of an armed conflict.

Conflict risk assessment studies usually aim to find the relation between the risk of an armed conflict and a given set of indicators, such as:

- Economic indicators (GDP, GDP growth, exports, and imports);
- Demographic and societal indicators (total population, population density, life expectancy, infant mortality, school enrolment, social fractionalization, etc.);
- Political indicators (regime type and duration, involvement in international organizations, peace duration, political rights, neighboring countries in war, etc.); and
- Environmental factors (spatial dispersion of the population, mountainous terrain, forest cover, cropland area, irrigated land, etc.).

Some variables can already be seen as correlates of risk of war such as infant mortality and life expectancy. We must, therefore, be careful in interpreting the regression results.

Once the regression model is estimated, it might be used to predict the probability of conflict outbreak and be used operationally to warn about the risk of war in any country. The current contribution also provides a discussion on the relevance of predicted probabilities and their contextual interpretation.

Method

Most empirical conflict studies aim to predict the probability of conflict onset based on a set of risk factors. In that case, the dependent variable is commonly coded 0 for all country-years records with no war, 1 for the year a war started, and missing for periods of ongoing war (Hegre and Sambanis, 2006; Collier and Hoeffler, 2004; Beck et al., 2000; Goldstone et al., 2005; Bennett and Stam, 2000), whereas some authors code these periods as 0 (Fearon and Laitin, 2003). Other studies consider modeling the *incidence* of armed conflict and the dependent variable is coded 1 for all periods of ongoing war (Reynal-Querol, 2002; Elbadawi and Sambanis, 2002; Hauge and Ellingsen, 1998; Urdal, 2005). The first approach is theoretically the most appropriate for modeling the probability of conflict onset, which is the risk of a new 'country-conflict' occurrence. However, in practice, it turns out to be inefficient.

First, the start and end dates of a conflict depend on the criteria used in building the conflict dataset. For instance, the International Peace Research Institute Oslo (PRIO) dataset records a conflict above the threshold of 25 battle-related deaths a year or 1000 deaths in total (Gleditsch et al., 2002).

Second, removing periods of ongoing war reduces the sample and especially the number of cases. This is critical because the number of cases is already small. For instance, we have 843 cases in total between 1971 and 2004 whereas there were only about 70 new cases, compared to about 7,600 total country-years records. Some scholars argued that the different approaches gave similar results at least when studying the effect of particular factors (Urdal, 2005; Hegre and Sambanis, 2006), but did not provide details of their evidence. In this study, we preferred a third design and coded all ongoing war periods as 1.

As independent variables, we selected 21 structural indicators: the GDP *per capita* (*gdpc*), GDP growth (*gdpg*), merchandise exports (*expm*), exports of goods and services as a percent of GDP (*expgdp*), merchandise imports (*impm*), imports of goods and services as a percent of GDP (*impgdp*), fuel exports (*expf*), foreign investment (*inve*), official development assistance *per capita* (*odac*), official development assistance as percentage of Gross National Income (*odag*), total external debt (*debt*), total population (*popu*), population density (*pdens*), population growth

(*pgro*), secondary school enrollment (*secs*), religious fractionalization index (*ref*), religious polarization index (*rep*), ethno-linguistic fractionalization index (*elf*), ethno-linguistic polarization index (*elp*), democracy level (*democ*), and accessibility index (*geog*).

These factors are the most studied and have been shown to be related more or less to the risk of armed conflict. The availability of data was also taken into account for the variable selection. The literature review on which this selection is based and a discussion of data sources are detailed in Burnley and Kayitakire (2007).

We checked the distribution of all the variables and transformed the data for normalization and variance stabilization. They were then standardized to mean 0 and variance 1. Some variables had missing observations simply because they had not been reported. For example, if exports data are missing for a country, and for some years, we can reasonably assume that this country actually did export, but did not report the statistics. We used a Markov Chain Monte Carlo (MCMC) method (Schafer and Olsen, 1998) that assumes multivariate normality to impute all missing values. Missing values for any variable are predicted taking into account the correlation between all variables used in the imputation model. Therefore, multiple imputation preserves the relation between variables and accounts for uncertainty in the model by creating different complete datasets.

Risk related to structural factors

Let Y_{it} be a random variable that records the event "an armed conflict occurs in country *i*, in year *t*", so that

$Y_{it} = 1$ if the event is realized (armed conflict), and
$Y_{it} = 0$ otherwise (peace).

We are interested in $\pi_{it}=P(Y_{it}=1)$, the probability that an armed conflict occurs in country *i* in year *t*. As we do a panel analysis, we can draw the subscript *t*. We need to estimate π on the basis of some explanatory variables (or covariates) $\mathbf{x} = (x_1, ..., x_r)$. These explanatory variables are typically structural indicators such as income measures, regime type, social fractionalization index, etc.

$$f(\pi) = \sum_{j=1}^{r} x_j \beta_j$$

We suppose that the dependence of π on $\mathbf{x}$ occurs through the linear combination:

The logit function is the most appropriate to model this dependence as it bears several interesting properties (McCullagh and Nelder, 1995, p. 109). Thus, the regression model can be written as follows:

$$\log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_r x_r + \varepsilon$$

where β_j are the unknown model parameters and ε is the error term.

Risk related to previous conflicts

Countries that experience an armed conflict are more prone to another conflict in the future. This effect is usually taken into account by including a variable that reflects the history of conflicts (Mousseau et al., 2003; Gleditsch and Ward, 2005; Urdal, 2005). In this contribution, we propose to separate the effect of past conflicts from the effect of other independent variables. The risk related to past conflicts is hereafter modeled in an innovative way inspired by the capture-recapture methods that are used in ecology studies (Jolly, 1982; Seber, 1982). Interested readers can find the details of the approach in Burnley and Kayitakire, 2007.

Results

We considered several specifications of the model and data processing to select the method that offers the best trade-off between quality of fit and completeness in the possibility of prediction. We started with the naive model, including all the explanatory variables and using the original dataset before imputation of missing values. The observations with at least one missing variable were excluded from the analysis. The results of this first analysis show that the likelihood of armed conflict is significantly associated with the GDP growth rate, the ODA *per capita*, the ODA per unit of GDP, the level of foreign investment, the size of the population, the level of democracy and with the different indices of social fractionalization/polarization, except for the ethno-linguistic polarization index. The overall model fitting statistics denote an acceptable model. The coefficient of determination R^2, adjusted according to Nagelkerke (1991), of 0.28 is an acceptable value in social sciences. The Hosmer-Lemeshow statistics (Hosmer and Lemeshow, 2000) is sufficiently small (not statistically significant) denoting an overall good fit.

However, when we examined the coefficient estimates of the different regressors, we noted some 'inconsistencies' with commonly accepted hypotheses. The sign of the coefficient of *lodag* (ratio ODA/GDP) was negative (less assistance is associated with higher risk of armed conflict) whereas the sign for *lodac* is positive (more assistance is associated with higher risk of armed conflict). We expected similar values for both variables. The religious fractionalization index has also an 'unexpected' negative coefficient whereas the associated polarization index coefficient is in the

expected direction. Montalvo and Reynal-Querol (2005) observed the same pattern and interpreted this as conditional on a given degree of polarization, more religious diversity decreases the probability of a civil war. Indeed, a high number of different groups increase the coordination problems and therefore, given a level of polarization, the probability of civil war may be smaller.

Another 'inconsistency' with commonly accepted hypotheses is that the coefficients of most of the economic indicators (income, exportation and importation volumes, debt service) are not statistically significant at a five percent level. Some have 'unexpected' signs. Thus, *lgdpc, lexpm* and *limpm* are not significant, but have the expected sign whereas *ldebt* is not significant and has an 'unexpected' value. This is perhaps due to multicollinearity problems.

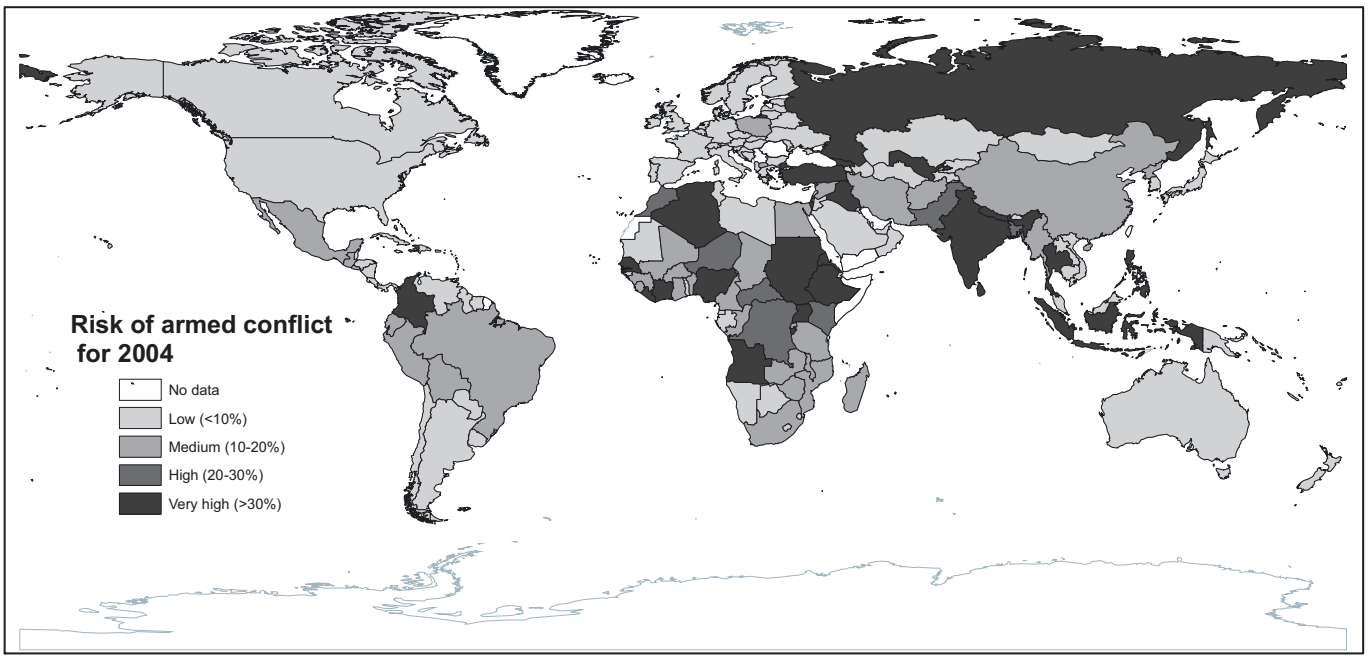
The results of the imputed dataset were almost similar with those of the basic model. The imputed dataset has a significant operational advantage because it provides estimates for many more countries. It was therefore used for the final predictions.

We noted that some factors had unexpected coefficient signs in the full models that are detailed in the previous section. Alternative specifications of the model, aiming to reduce multicollinearity effects, were tested: expert-judgment selection of variables, automatic forward stepwise variable selection, and principal components regression combined with a stepwise variable selection procedure. The latter approach was finally applied as it turned out to give the best results and was the most appropriate to operational application, which does not require an expert judgment and interpretation. It is worth noting that the variable selection yielded a model with six economic indicators (*lgdpc*, *gdpg*, *lexpm*, *lexpgdp*, *lodag*, *lodac*), three socio-demographic indicators (*lpopu*, *lref*, *lelf*), and the regime type indicator (*democ*).

For each country and for each year, we estimated the probability of conflict due to the conflict history. We finally took the average value between the probability estimated with the structural factor regression model and that related to the history of conflicts. This can be regarded as the overall risk of armed conflict given the socio-economic situation of the country in the recent past. Figure 1 shows the map of risk of armed conflict in 2004 as estimated in this study. Countries are classified into four categories with breakpoints defined as follows: low risk (< 10%), medium risk (10–20%), high risk (20–30%) and very high risk (> 30%). In the context of armed conflicts, we are talking about rare events (the cases represent seven percent of the observations), and probabilities greater than 20 percent can already be regarded as high (King and Zeng, 2001).

The estimates for some countries must be interpreted with caution as their socio-economic data were actually sparse. This is especially the case for Iraq and

Figure 1: Risk of armed conflict in 2004 as estimated by the help of the model used in this study (see above) and including data on previous conflicts.



Afghanistan. The model can be updated easily as new data become available.

On the basis of these results, we can note that the ten countries with highest risk are in the order India, Indonesia, Colombia, Nigeria, Nepal, Turkey, Ethiopia, Uganda, Sudan, and the Philippines. All these countries have indeed strong central governments that have been challenged for a long time by different kinds of rebellions. They will perhaps never explode into total war and collapse, but they remain somehow fragile. We think, however, that the model overestimates the risk for India and Turkey. Estimates on Turkey have been systematically high for the last 20 years, for India even for the last 30 years. In the same time frame, they showed a remarkable economic development. These countries succeeded in keeping the influence of their rebellions at a low level and concentrated on economic development rather than trying to resolve all conflict cases before moving ahead with economic activities. If current economic growth is maintained, the rebellion activities could be significantly lowered by the fact that the central government will have more capacity for investment in security forces and incentives for rebellion supporters to benefit from the country's economic prosperity. Low intensity conflicts can continue without really destabilizing the country. Such situations have been observed in Spain (Basque country), France (Corsica), Northern Ireland, etc.

Conclusion

At the beginning of this contribution, we hypothesized that a number of widely-used structural indicators might be strongly correlated with the risk of armed conflict in a country. Our study found that despite widespread discussion in academic papers, the most commonly used indicators (GDP growth rate, official development assistance, level of foreign investment, population size, level of democracy, and social fractionalization/ polarization) did not clearly emerge after regression analysis as causal factors, in part due to multicollinearity effects. Future work should address the reasons for these inconsistencies with the initial hypothesis. The method outlined may still be used operationally to estimate conflict probability and to predict conflict for countries for which structural data exists; results are as good as any currently in use. Estimated probability times series show that our model is consistent over time.

It is worth noting that while certain structural conditions may exacerbate already existing political tensions in a country, the mechanisms which then lead to conflict are not well understood and can be highly specific. For decision makers, the output of a conflict prediction model should be the location, time frame, impacts of conflict, and conflict response feedback effects. Models such as ours, using structural data, cannot produce such outputs; they make a static assessment of country level performance, which can then be ranked for conflict risk.

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Environmental Factors as Triggers for Violent Conflict: Empirical Evidence from the 'FAST' Data Base

Heinz Krummenacher

Research question

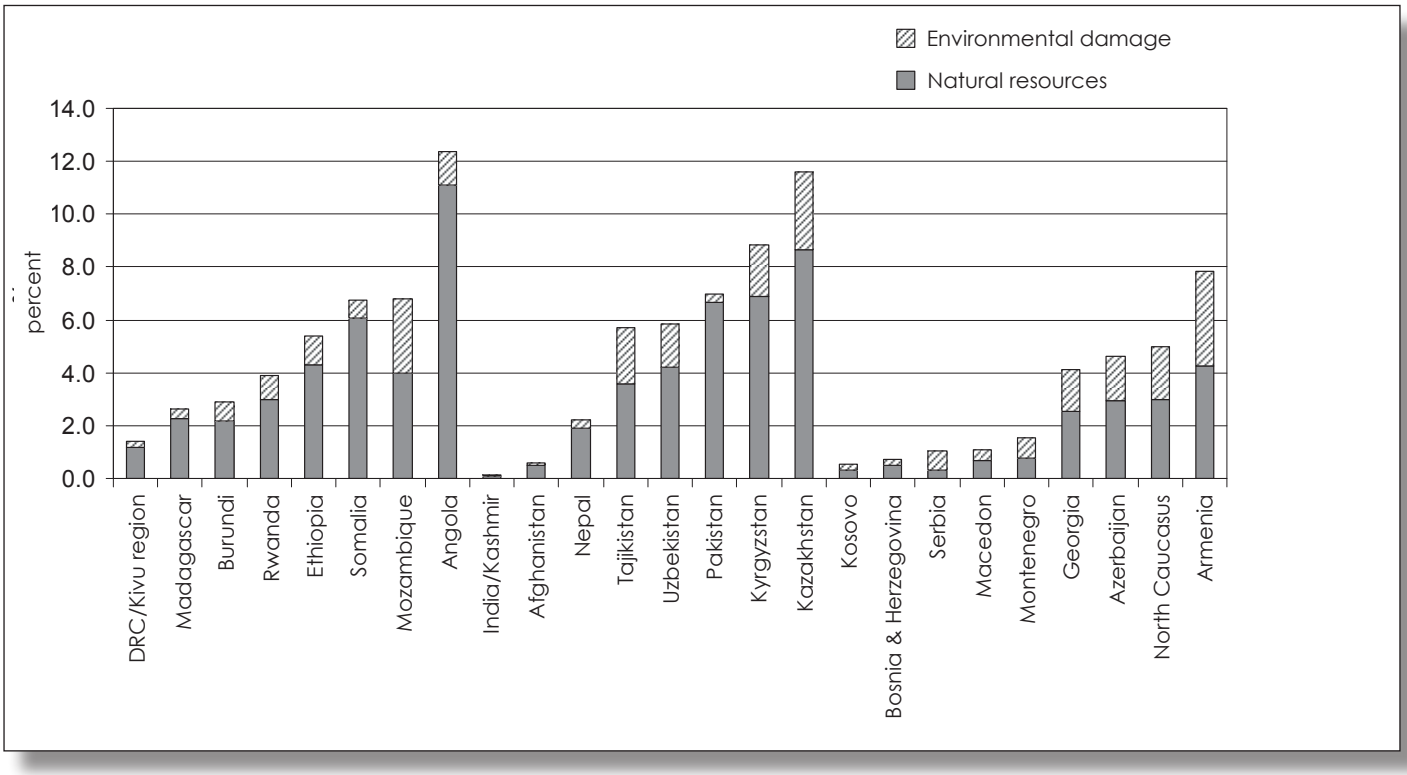
In the past decades, natural resources have attracted considerable attention as a source of conflict. Depending on the respective theoretical premises, some scholars have argued that scarcity of renewable natural resources inevitably leads to violence in countries of the global South. Others have tried to show that it is not scarcity, but abundance of natural resources which creates problems[1]. But are these scholars right? Is there a direct link between the lack of or the existence of natural resources and violence? In order to answer these questions, we looked at the FAST data base[2], which contains conflictive and cooperative data for over 20 countries, covering a time span in between four to six years.

Frequency of environment-related events

If we look at the percentage of events, which are somehow related to environmental issues (environmental damage and/or natural resources), we see at first glance a huge difference between the various countries. For example, in oil-rich countries such as Angola or Kazakhstan, more than eleven percent of all events, which from a conflict/cooperation viewpoint are considered to be relevant, are linked in one way or the other to the environment. On the contrary, in countries such as Afghanistan, India/Kashmir, or Kosovo, this percentage tends to be much less; indeed it is almost nil (see Table 1). Overall, the percentage of events with an environmental background is 4.5, with around 3.5 percent falling in the category of 'natural resources' and only around one percent of all events is tied to environmental damage.

These results coincide with an earlier study we conducted within the ENVSEC[3] program on the Ferghana Valley. There, we found that out of the approximately 2,000 events, eight percent were related to 'natural resources' and three percent to 'environmental damage'. Thus, the Ferghana Valley shows a slightly higher incidence of environmentally-caused conflictive/cooperative

Figure 1: Percentage of environmentally-induced events to all events



[1] For an overview regarding the competing concepts, see Brauch, 2008, pp. 27–45.

[2] FAST (*Früherkennung und Analyse von Spannungen und Tatsachenermittlung* or Early Recognition of Tensions and Factfinding) is an event data-based political early warning program covering 25 countries/regions in Africa, Asia, and Europe. Its objective is the early recognition of potential crisis situations and windows of opportunity for peacebuilding. FAST was run by Swisspeace on behalf of a number of development agencies in Europe and North America. For further information see <http://www.swisspeace.org>.

[3] The ENVSEC-initiative is a point program by UNEP, UNDP, OSCE, UNECE, REC, and NATO that has three key objectives: (1) assessment of environment and security risks, (2) capacity-building and institutional development to strengthen environmental cooperation, and (3) the integration of environmental and security concerns and priorities in international and national policy-making (for further information see: <http://www.envsec.org>).

events than the average of the 25 countries, which were monitored within the FAST program.

Frequency of environment-related events per event type

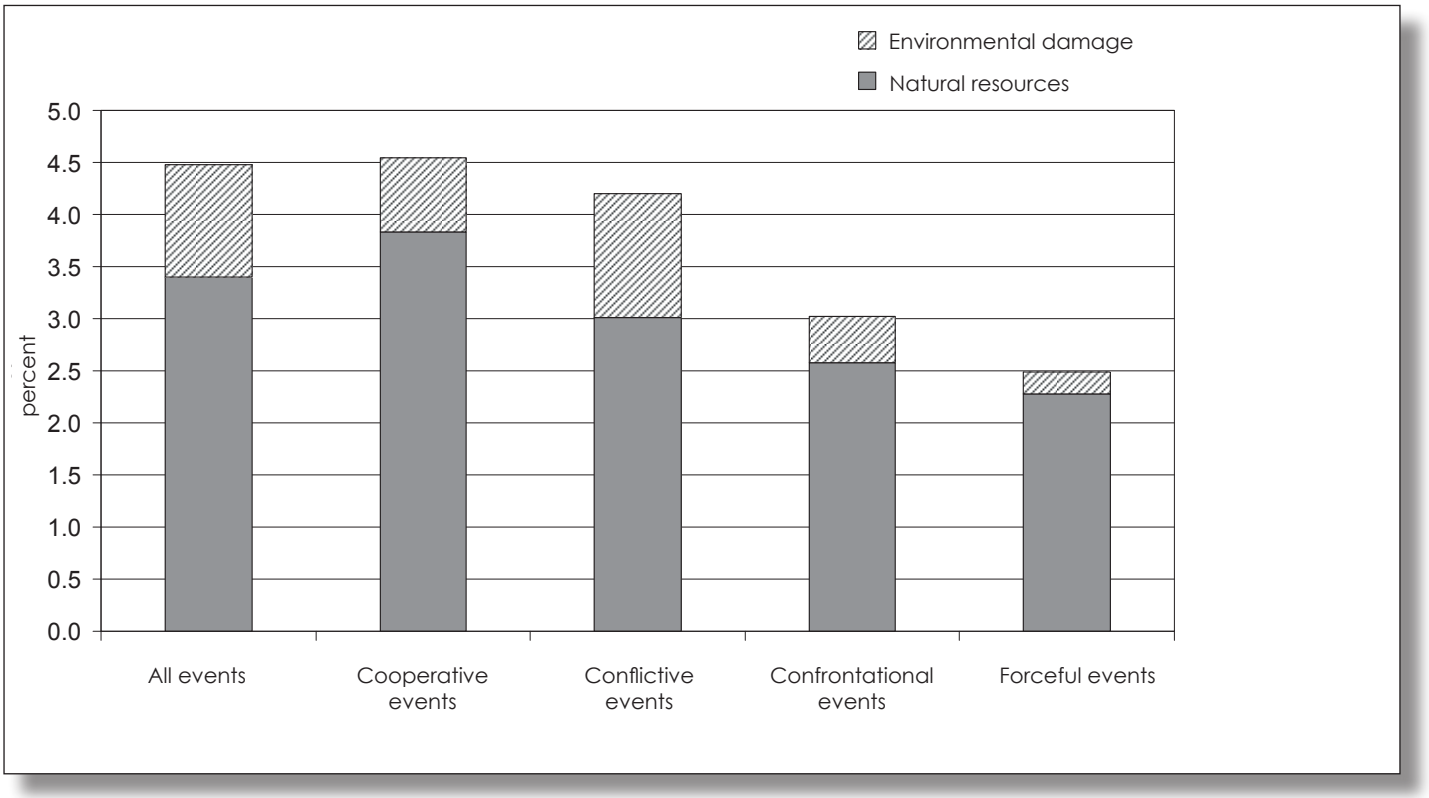
Assessing these results, it is important to keep in mind that the FAST data base contains exclusively events that are of importance to the escalation or de-escalation of sub-national, national, or international conflicts. This means that we do not only store events that comprise the use of force or violence, but also events that contribute to an easing of tension, the de-escalation of conflict, and/or peacebuilding. Thus both, conflictive, confrontational, and forceful events as well as cooperative events can have an environmental dimension. Table 2 shows that half of the events that have an environmental/resource aspect are of a cooperative nature (cooperative vs. conflictive, confrontational, or forceful events). Violence as such (that is events, which entail force) amounts to 2.5 percent of all events only, while cooperative events account for 4.5. percent of all events.

Again, the Ferghana example reveals some other interesting facts. In the Tajik and Uzbek parts of the Ferghana Valley, we observe a pattern that resembles the global trend—salient environmental events are mostly linked to conflict. Nevertheless, this does not hold true for the Kyrgyz part. Here, the links between reported environmental events and cooperation are slightly stronger. Hence, Kyrgyzstan might be an interesting testing ground for examining environmental factors conducive to peace.

Conclusion

What are the main results of our very cursory descriptive analysis of the FAST conflict and cooperation data from an environmental perspective? First, given that only 4.5 percent of all relevant events are linked to environmental issues ('natural resources' or 'environmental damage'), empirical evidence suggests that there is actually no direct link between environmental parameters and political violence. Environmental factors undoubtedly play a crucial role in explaining political escalation and de-escalation processes. The causal relationship,

Figure 2: Event type and environment



however, is not linear. Neither the scarcity of land or water nor the abundance of oil or gas drives a society straight down the road to violent conflict. Resources like water and land or environmental damage can be important ingredients in a complex blend of political, cultural, and economical factors that eventually breed violence.

The institutional settings of the societies concerned, the structure and type of political authority, as well as global mechanisms at play and the historical context are just as important as, if not more, the actual availability of land or water in both explaining and resolving conflicts. Trivial as it may seem, this point is actually of crucial relevance given the propensity of decision-makers and policy institutions to draw on single-sided resource scarcity or resource abundance-based arguments and discourses.

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3 Treaty Monitoring Based on Geographic Information Systems and Remote Sensing

Monitoring Multilateral Humanitarian Agreements

Stefan Schneiderbauer

The purpose of this contribution is to highlight both the potential and limitations of remote sensing techniques in support of the monitoring of humanitarian agreements. After a short introduction highlighting the main objectives of humanitarian law and human rights, a description of some current monitoring activities is provided. The practicality of using earth observation (EO) in this context is then discussed with some examples.

Legal background

Humanitarian agreements are embedded in humanitarian laws, established (1) to protect persons who are not or no longer directly engaged in hostilities and (2) to limit the impact of the violence undertaken to achieve the objectives of a specific conflict (United Nations, 1991). International humanitarian law is part of international law, which is the body of rules governing relations between states (ICRC, 2004). It is contained within accords that are labeled with various terms according to their level of legal obligation, namely agreements, treaties, and conventions. With a growing international community, an increasing number of states have contributed to the development of these obligations and committed themselves to complying with them. As a result, the international humanitarian law today forms a universal body of law, of which The Geneva Conventions of 1949 and their Additional Protocols of 1977 are the main instruments.

It is important to differentiate between international humanitarian law and human rights law (ICRC, 2002) (in the following called 'human rights'). Both types of legal obligations developed separately and are contained within different agreements. Most significantly, the international humanitarian law applies only in times of conflicts whilst human rights apply anytime—be it in war or peace. The overall objective of human rights is to protect individuals from arbitrary behavior by their own governments. The protection of these rights is one of the central ideals of the United Nations (UN). Therefore, the UN member states have concluded seven major human rights agreements. The most important instruments within these agreements are the Universal Declaration of Human Rights (1948), the International Covenant on Economic, Social and Cultural Rights (1966), and the International Covenant on Civil and Political Rights (1966).

Monitoring challenges

To sign a treaty and to comply with its legal obligations are often two sides of the same coin. The sad reality is that governments often sign treaties, but do not comply with them—countless examples of international humanitarian law and human rights violations prove this point. Therefore, it is as urgent as ever that we keep striving for effective monitoring that will prove the compliance with or defiance of humanitarian agreements.

Monitoring, as an activity undertaken to evaluate the compliance of humanitarian law and human rights, comprises the collection, verification, and immediate use of relevant information (United Nations, 1997). In very general terms, monitoring information in the case of humanitarian law includes a description of conflict-related events and their impact on civilians. In the case of human rights, monitoring information includes the observation of situations that are relevant to a particular convention (torture, racial discrimination, discrimination against women, rights of the child, etc.). Monitoring activities would typically focus on relevant incidents and events (elections, trials, demonstrations, etc.) or concentrate on certain regions or a certain population group at risk/potentially affected, for example, refugees or IDPs in a camp.

'Direct' versus 'indirect/remote' monitoring

Classical monitoring activities are based on 'direct' approaches, that is they rely predominantly on information collected on the ground and from affected people. For example, UN Human Rights Officers pursue their monitoring tasks by undertaking field visits, including interviews with knowledgeable individuals, human rights organizations, other non-governmental organizations (NGOs), local government officials, and other relevant actors, or by gathering information from reports (provided by state parties, mandated NGOs or individual complaints). The media, as a means of representing and summarizing journalists' observations, is an additional important source of information.

In contrast, monitoring by means of remote sensing technology and the analysis of earth observation data is an indirect observation methodology that gathers data from a certain distance, usually several hundreds of kilometers away. Satellite images have been exploited traditionally in the context of international law for the verification of disarmament and arms control treaties (Hettling, 2003). During the last 10–15 years, the potential of spaceborn data with regard to supporting monitoring of humanitarian law and human rights, has considerably increased due to (1) the enhanced technical capabilities of satellites and sensors (namely spatial and temporal resolution) and (2) the commercialization of the remote sensing industry, which has led to both a vast amount of data being made available and improved access to this data, making it attainable to all interest groups. As a result, the use of such data, in particular by NGOs, has increased significantly. Examples include data analysis to

- Identify infrastructure damages, mass graves, and natural resource degradation in conflict/crisis situations;

- Track population movements;
- Detect toxic waste dumping and landmines (the latter still being topic of research activities).

However, there are a number of legal, political, and technical issues that need to be considered when applying spaceborn data for humanitarian purposes and these will be discussed in the following paragraphs.

Both direct and indirect monitoring approaches have their advantages and disadvantages and are of greater or reduced suitability under particular circumstances. Ideally, both methods should be used to complement one another.

The greatest advantage of satellite images is their potential to provide data in situations when field work is not desired, not affordable or for some reason not possible. For example, spaceborn data can be used over areas where the authorities do not accord access or where field work is too dangerous to conduct due to ongoing fighting or the presence of landmines. When field access is not possible, remote sensing technology is often used as a last means for obtaining data on the latest developments in the area at stake. An additional major advantage of earth observation is the provision of spatial data that allows for an overview of a larger area. EO data also provides information on the spatial extent of events and may help bring a focus to subsequent field work.

The data gathered from field work or reports differ significantly from those recorded by space sensors. Remote sensing data are—at least in their raw and unprocessed format—unbiased, verifiable, and comparable, a fact that has great advantages for a systematic analysis. Furthermore, a satellite image always represents exclusively and exactly the situation as it appeared at the moment of data reception. The satellite's travel on its orbit allows repetitive scans of the same area, with the possibility to frequently acquire data covering an area of concern. It therefore provides the opportunity to carry out continuous investigations and the detection of changes within defined time intervals.

Yet, the data gathered through satellite imagery is always reduced to what is visible from above and only to physical objects. Clearly, one cannot see people's fear, anguish, agony or despair, nor is it possible to detect torture instruments or practices going on underneath a person's roof. To use earth observation most efficiently and effectively, it is best recommended that one obtain basic field information in order to know where and what area to investigate.

In contrast to remote sensing, the information received through reports, inspections, and interviews is far more subjective, hard to analyze quantitatively, and more difficult to be repeated. However, such information mostly contains qualitative information, which cannot be gathered through remote sensing. In field work, people can provide a holistic overview of a situation, they can summarize and point out the most important issues, and they can also give a condensed retrospective of a long(er) time period. In certain cases, field work campaigns may gain substantially from EO data analysis carried out before *in-situ* visits as EO data allows them to focus on areas most affected by violent events.

Applying EO data for monitoring purposes is expensive. The minimum price for a very high resolution satellite image is US $7 (IKONOS) or US $15 (Quickbird) per km^2. The costs increase for geo-referenced or in any other way pre-processed data, as well as for any specially requested image orders. Moreover, special software and expertise is required to analyze the data. Nevertheless, the total costs of a field work campaign in terms of time, equipment, and personnel usually outweigh the expenses of remote sensing products especially when required observations need repeating and/or cover a larger area.

Remote sensing data usability

Even though satellite sensors acquire data continuously whilst traveling in their orbit, the availability of data useful for monitoring humanitarian conditions depends on a number of prerequisites:

- **Weather dependence:** The majority of very high resolution sensors applicable for monitoring of humanitarian issues receives the visible portion of the electromagnetic spectrum and only delivers undisturbed images in cloud-free weather conditions.
- **Shutter control:** Following their own political interest, governments may put pressure on companies based on their territory to temporarily or permanently restrict or stop the distribution of images on particular geographical areas. Most well-known examples are the purchase of exclusive rights to all images over Afghanistan from Space Image's Ikonos by the US National Geospatial-Intelligence Agency and the prohibition of the sale by US firms of optical satellite data of Israeli territory with less than two-meter resolution.
- **Permissibility of space born data acquisition:** Despite the Outer Space Treaty of 1967 and the UN Principles relating to Remote Sensing of the Earth from Space (adopted in 1986), there is uncertainty about the legal regime for the unrestricted rights to remote sensing without prior consent or notification. As a result, countries under observation may not accept investigations from space (Hettling, 2003).
- **Impartiality of satellite images:** Although the satellite data is gathered in an 'objective' manner, the final image presented on screen or paper is a result of a number of analytical steps carried out by remote

sensing experts. As with any photograph, at the end of the day it is a subjective interpretation of reality. Moreover, the image processing steps open the door for manipulation in the same way as is possible with any digital photo. Therefore "the real legal value […] of satellite imagery is not absolute" (Taillant and Picolotti, 1999, p. 10).

As a result, it is often not possible to obtain the required EO data type that covers the area of interest to a sufficiently high quality and within the desired time period. Consequently, if not absolutely necessary, no monitoring system verifying humanitarian treaties should be set up relying exclusively on EO data. For the time being, the predominant role of satellite imagery for such monitoring activities is (still) the provision of additional data layers for authentification purposes.

The following three examples demonstrate the potential of remote sensing data to support monitoring of humanitarian agreements in certain circumstances.

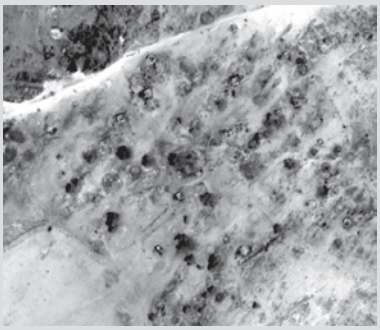
Humanitarian crisis in Darfur

The humanitarian crisis in Darfur results from conflicts between various ethnic and tribal groups in West Sudan. The Sudanese government is involved in this conflict and is accused of having violated human rights in multiple ways. According to Amnesty International (ai), the conflict in Darfur "has led to some of the worst human rights abuses imaginable, including systematic and widespread murder, rape, abduction and forced displacement" (Amnesty International, 2007). The number of people reportedly killed varies between several thousands and hundreds of thousands; the numbers given of people displaced vary in similar ranges.

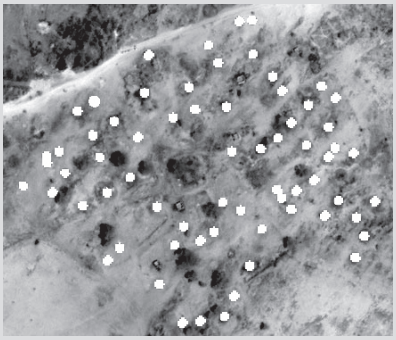
In order to prove the demolition of villages and the rapid growth of refugee/IDP camps, Amnesty International has put up a website with a number of very high resolution satellite images representing certain areas in Darfur in 2003/2004 and 2007 respectively. Cut outs of these images show villages that were partly or fully destroyed or they highlight the development of refugee/IDP camps within this time period. ai provides an 'attack summary' giving ancillary information (for example the type and the date of the violent event) and a damage assessment based on change detections of the two images listing the number of structures 'destroyed' or 'likely destroyed'. ai also claims to have verified its analysis where possible through eyewitness accounts and on-the-ground photographs. Figure 1 a–c gives an example of the village Ishma close to Nyala, the capital of South Darfur.

Figure 1: Satellite images and damage assessment in Ishma in South Darfur / Sudan

a) Quickbird image from 2004



b) Quickbird image from 2007



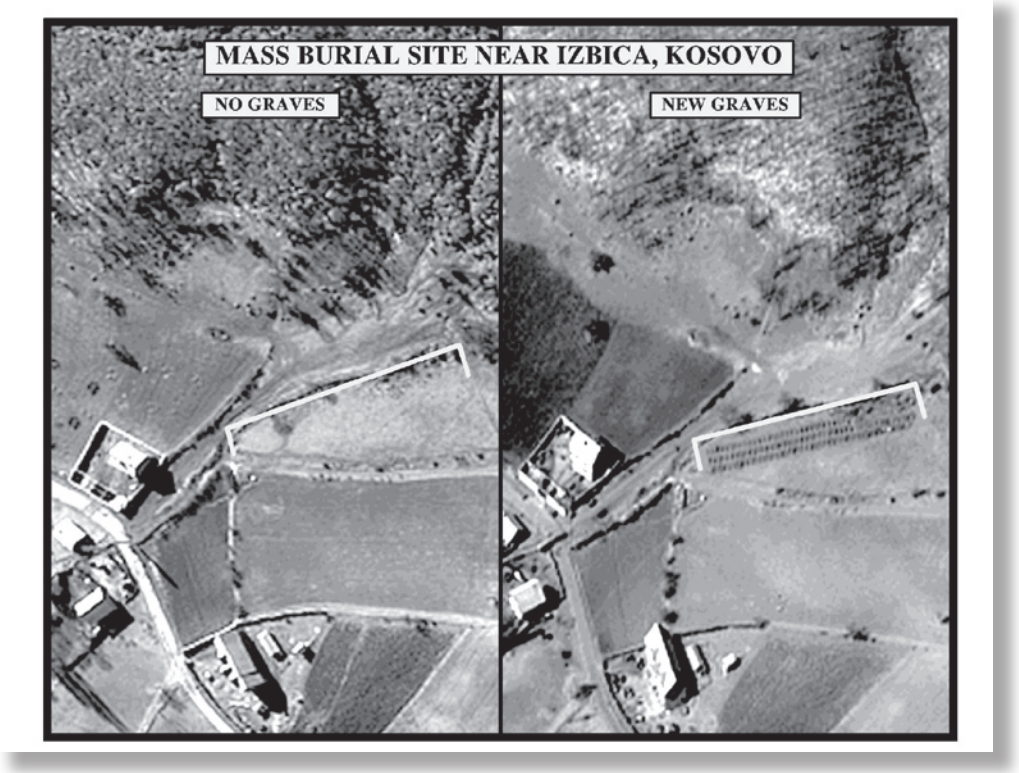
c) Damage assessment provided by ai based on change detection of the images represented in Figure 1a) and Figure 1b). The white dots mark destroyed structure.

Source: © Digital Globe 2008. Images taken from <www.eyesondarfur.org>. Amnesty International, American Association for the Advancement of Science.

Ethnic cleansing in Kosovo

During the Kosovo conflict, the photograph in Figure 2 was presented to the public by NATO in order to prove ethnic cleansing activities under the rule of the Serbian President Milosevic. The Kosovo conflict started in 1997 and was fought by the Kosovo Liberation Army to achieve independence from Serbia/Yugoslavia. In 1999, the Serbian army killed several thousand people from the Kosovo population and 150,000 Kosovo Albanians were reported to have been made homeless. In order to force the Serbian government to end the civil war in Kosovo, NATO carried out a military operation called "Operation Allied Force" with bombing campaigns that lasted from March to June 1999. In a press release from the Operation Allied Force on 14 May 1999, a number of aerial photographs were published to confirm Milosevic's crimes against humanity and to justify military operations against the Yugoslavian government. Figure 2 shows a mass burial site close to Izbica in Kosovo, which had a great impact on the media and public opinion (Willum, 1999).

Figure 2: Photograph from April 1999: A mass burial site in Izbica, Kosovo.



Source: http://www.globalsecurity.org/intell/library/imint/990514-view.htm (viewed November 2007)

Operation Murambatsvina in Zimbabwe

On 19 May 2005, the Government of Zimbabwe and its president Mugabe embarked on an operation known as "Operation Murambatsvina" or "Operation Clean-up" literally translated as "getting rid of the filth". This 'operation' had allegedly been carried out in order to weaken political opposition, namely the urban poor, and prevent mass uprisings against the rapidly deteriorating political and economic conditions in Zimbabwean's cities. Within a very short period of several weeks, this operation led to an estimated 700,000 people losing their homes, their source of livelihood, or both (United Nations, 2005). Many more were indirectly affected, most of them belonging to the poorest and most disadvantaged members of the Zimbabwean society.

Figure 3 shows destroyed houses in Mbare Township, Harare, Zimbabwe. The damage assessment was undertaken by UNOSAT. It is based on a Quickbird and an IKONOS satellite image, one taken before Operation Murambatsvina (16 April 2005) and one during it (27 June 2005). In the case of Murambatsvina, satellite image interpretation helped the humanitarian community to understand the extent of the operation's impact. Additional image analysis carried out one year later supported the fact that only a tiny fraction of destroyed houses had been rebuilt within the scope of the reconstruction program 'Garikai' launched by the Zimbabwean government in 2006.

Figure 3: Destroyed houses in Mbare Township, Harare, Zimbabwe.

a) Photo-interpretation of a Quickbird image (16 April 2005)

b) Photo interpretation of an IKONOS image (27 June 2005) for damage assessment

Source: UNOSAT: http://unosat.web.cern.ch/unosat/asp/prod_free.asp?id=29 (viewed November 2007)

Conclusion

Remote sensing technologies, in particular very high resolution space-born images, are able to support monitoring of humanitarian agreements. When field visits are not possible, they are one, if not the only option to receive data of the latest developments on the ground. Satellite images can provide a comparable, mostly verifiable, unbiased, and continuous data source allowing for monitoring and change detection work of the earth's surface. They are in particular useful when large areas on the ground need to be observed frequently. However, space-born images are only able to provide information on physical objects and the availability of EO data in sufficient quality within a requested time period is not assured. In most cases of human rights monitoring and humanitarian law compliance verification, satellite images represent one of a number of valuable and complementary data sources. They do not by any means replace *in-situ* inspections and personal inquiries.

The ultimate task of monitoring humanitarian issues is to 'find out the facts'. Remote sensing has the potential to contribute to this task, but the added value obtained by applying EO data depends on (1) the knowledge and experience of the remote sensing experts who are responsible for the technical analysis of the data and (2) the ability of the political experts who integrate the results of the analysis in their political context and who create a holistic view of the situation.

Overall, the potential of remote sensing data for monitoring humanitarian agreements has surely not yet been fully exploited. Moreover, new technological developments such as the availability of very high resolution radar sensors (TERRASAR-X and COSMO SkyMed) are permanently augmenting the capabilities of EO data for this purpose.

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Monitoring Environmental Agreements and Conventions

Peter Zeil, Hermann Klug, and Irmgard Niemeyer

Introduction

The importance of environmental security

The monitoring of the environment for safeguarding human security and stability has to be consistent with national policies. Furthermore, decisions such as the ones made by the European Union at the summit in Goteborg dedicated to the topics of sustainable development in Europe (European Council 2001), have to be implemented in national programs to enforce action. However, the first step towards action is the knowledge about laws and conventions existing so far and the potential and feasibility of earth observation and GIS capabilities to facilitate the task at hand. In order to reach a consistent approach to future monitoring for environmental security, considerable efforts are already on the way to investigate opportunities and potentials earth observation methodologies hold to serve reporting and evaluation. These efforts are:

- Analysis of threats to human security arising from natural and human-induced hazards;
- Incorporation of research, capacity-building, and policy-relevant advisory activities relating to the broad interdisciplinary field of risk and vulnerability assessment including early warning systems;
- Monitoring of environmental changes, such as desertification, which put pressure on social, economic, political, and demographic dynamics triggering insecurity;
- Searching for strategies to cope with desertification as a worldwide problem. It is directly affecting over 250 million people, and often causing migrations as one-third of the earth's land surface (over four billion hectares), is threatened by degradation (Asian Development Bank, 2008).

The livelihoods of 1.2 billion (10^9) people depend on land for most of their needs and due to this fact, the world's poorest in over 110 countries are threatened (GDRC, 2008).

Definitions

To understand the different terms, we define laws, conventions, declarations, regulations, treaties, agreements, principles, and directives as:

Law: A rule of conduct or action prescribed or formally recognized as binding or enforced by a national (country) or international (EC) controlling authority. It is a command or provision enacted by a legislature, something (as a judicial decision) authoritatively accorded binding or controlling effect in the administration of justice.

Convention: A binding agreement between nations for the regulation of matters affecting all of them. It is generally used for formal multilateral instruments with a broad number of parties in an agreement enforceable in law (contract).

Declaration: A statement proclaiming the principles, aims or policies of a group or government and sometimes more concrete, a statement made by a party to a legal transaction e.g., the attorney must later sign (ratify) an affidavit or declaration stating that he has notified the consequences of the declaration in written form. Furthermore, it can be a statement creating or giving notice of the creation of a legal entity, relationship or status and the instruments embodied in such a statement.

Regulation: A regulation is an authoritative rule or order issued by a government agency, frequently having the force of law. Hence, an agency is often delegated the power to issue regulations by the legislation that created it. Regulations must be made in accordance with prescribed procedures, such as those set out in the federal or a state Administrative Procedure Act.

Treaty: A treaty according to the United Nations (1999) and UNEP (2008) is an international agreement concluded between one or more political authorities (as states or sovereigns) in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation (Vienna Convention on the Law of Treaties). It is an arrangement made by negotiations and formally signed by representatives duly authorized and usually ratified by the legislative authority of the state.

Agreement: An agreement is a generic term for an international legally binding instrument. In this sense, it encompasses several instruments, such as treaties, conventions, protocols, and oral agreements. In a narrower sense, an agreement is a specific term used to designate international instruments that area usually less formal and deal with a narrower range of subject matter than treaties such as unities of opinions, understanding or intent.

Principle: A fundamental law, rule or common strategy as a guide to action. Principles conduct a fundamental motive or consciously recognized reason around a commonly formulated concept based on social, political, economic, and environmental values incorporating scientific knowledge. Usually principles are expressed concisely and succinctly. One example is the sustainable development principle negotiated at the World Summit.

Directive: A communication, order or instruction in which policy is established or a specific action is ordered by a central authority. An obligatory pronouncement to encourage, discourage or even ban some activities with the aim to govern tasks towards an intended objective.

Multilateral environmental agreements

The international community has signed more than 500 international treaties since the United Nations Conference on Human Environment in Stockholm 1972 (see Figure 1). Most of these Multilateral Environmental Agreements (MEA) have been negotiated and ratified and therefore oblige parties, directly or indirectly and to a different extent, to implement procedures for monitoring and assessing the status of the environment on a regular basis as well as report about their efforts to combat environmental degradation.

As Aschbacher (2002) argues, earth observation (EO) generally represents a key source of information for the different national and international bodies involved in the implementation of environmental treaties. Hence, EO technology may contribute significantly towards achieving the objectives of multilateral environmental agreements by:

- Increasing scientific and technical knowledge about the environment;
- Supporting the efficient management of environmental problems;
- Contributing to improve the performance of the Convention.

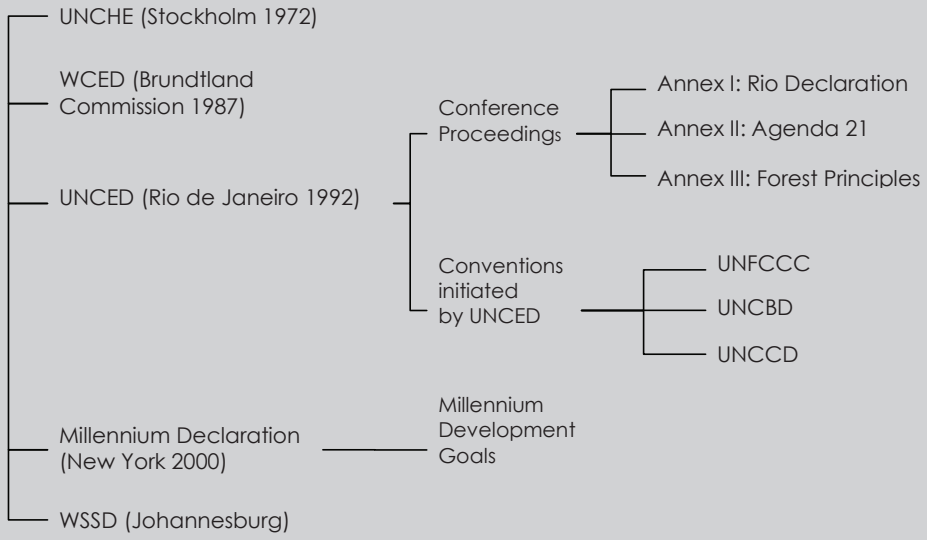
Millennium Ecosystems Assessment

After the 1992 UNCED Conference in Rio de Janeiro, the Millennium Ecosystem Assessment (MA) was called for by United Nations Secretary-General Kofi Annan in 2000 in a report to the General Assembly entitled "We the Peoples: The Role of the United Nations in the 21st Century." Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for human well-being and outline the scientific basis for actions needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. This major undertaking involving more than a thousand experts worldwide yields a baseline for the assessment of change and moreover, elaborates the likelihood of impacts on the ecosystem as a resource base for human livelihoods. The harmonized analysis required the use of remote sensing data to establish land cover and land use over waste areas.

EUR-LEX, ROD and reporting status

UNEP (2001) presents a list of the 41 core environmental conventions related to agreements of global significance and 13 regional seas conventions and their juridical status. For the European Union, the EUR-Lex system[1] provides direct access to EU directives

Figure 1: Development of international treaties in a temporal overview



UNCHE: UN Conference on the Human Environment; WCED: World Commission on Environment and Development; UNCED: UN Conference on Environment and Development; WSSD: World Summit on Sustainable Development; UNFCCC: UN Framework Convention on Climate Change; UNCBD: UN Convention on Biological Diversity; UNCCD: UN Convention to Combat Desertification

facilitating the consultation of the Official Journal of the European Union with reference to respective treaties, legislation, case law, and legislative proposals.

The Reporting Obligations Database (ROD)[2] of the European Environment Agency (EEA) contains records describing environmental reporting obligations of member states towards international organizations. The Environmental Information Portal[3] and UNEP/GRID-Arendal[4] provide an overview of the environmental reporting process and nation-wide assessments.

UNEP's Global Environment Outlook (GEO) is a consultative, participatory, and capacity-building process for global environmental assessment and reporting on the Status of the Environment (SOE), trends and future outlooks.[5] GEO is both a process involving stakeholders from across the globe, as well as a product for environmental decision-making. It aims to facilitate the interaction between science and policy. Since its inception in 1995, four reports have been published (GEO-1 to 4), the latest on 25 October 2007.

A worldwide network of collaborating centers forms a strong assessment partnership at the core of the process and a focus for capacity-building at various levels. Comprehensive peer review and consultative mechanisms with governments, non-governmental organizations (NGOs), and scientific institutions are some of the other integral elements of GEO. Advisory groups provide guidance on conceptual approaches and methodology development and capacity-building.

This participatory and consultative process gives GEO assessments scientific credibility, policy relevance, and authority. It targets a wide audience by providing information to support environmental management and policy development.

GEO has many other impacts. It supports multi-stakeholder networking, provides a platform for the exchange of data[6] and knowledge, promotes intra- and inter-regional cooperation in identifying and addressing key environmental issues and concerns and builds capacity at many levels.

Methods

The names of the assessments say it all: Global Environmental Outlook, Human Development Report, World Water Development Report—we want to know the status and the rate of change. Only then can intervention options be developed and evaluated. Partly, the MEAs have laid down the procedures for monitoring already. Others have still to design the rules for reporting. At the heart of all assessments/monitoring efforts are two factors:

- A set of critical indicators which reflect the specific status;
- The data to enumerate these indicators and to monitor their change.

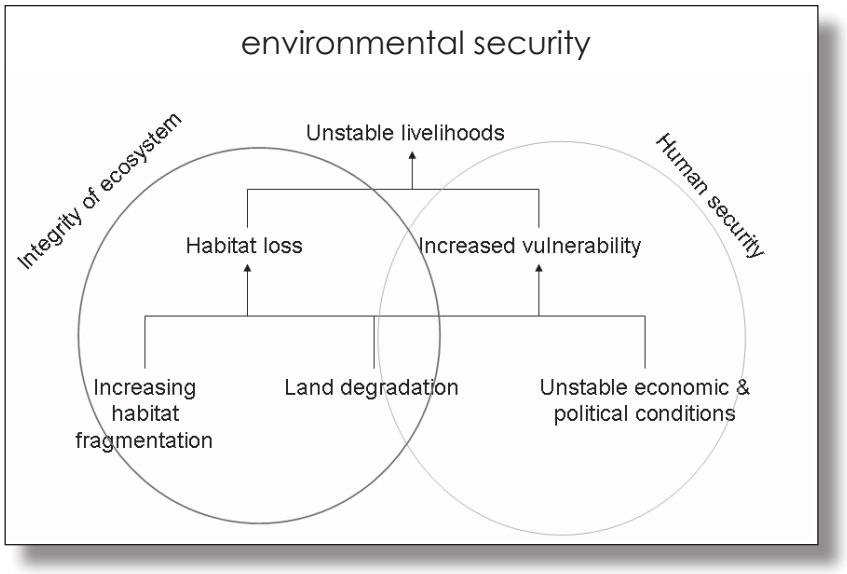
Under the umbrella of the United Nations, an initiative has recently been started to consolidate a set of key indicators from individual assessment efforts with the aim to allow multiple use of observational data. Reference can be found under the United Nations System-wide Earthwatch mechanism, which is a broad UN initiative to coordinate, harmonize, and catalyze environmental observation activities among all UN agencies for integrated assessment purposes.[7] Certain subsystems represent the Sustainable Development Indicators-Interagency Working Group[8] and the Inter-agency and Expert Group on MDG Indicators.[9]

Working towards harmonized assessments, observational tools are required which provide the data for selected indicators and if we consider applications for monitoring environmental security (Figure 2), they have to be transparent, independent, and globally available.

Satellite images taken from space have a number of distinct advantages compared to ground-based measurements (the following is adapted from Aschbacher, 2001). They are rigorous measurements based on the electromagnetic spectrum of the earth surface *taken remotely* from satellites on a sun synchronous or geostationary orbit. Therefore, *continuous* monitoring and long-term operation of different parts of the world is possible and secured without having an agreement or consent with the respective country. Especially, the large spatial extend possibly covered by EO measurements helps close gaps in space and time providing a more integrated picture of our global environment. The satellite passing the same area in a certain *repeat cycle* of measurement (time sensitivity); the information gathered is *comparable* and procedures can be applied repeatedly. However, processing of raw earth observation data needs to be constructed around an agreed body of *verifiable/ reasonable* evidence, which represents the real world at an appropriate *level of abstraction*. To be used effectively, the agreed goals laid out in the conventions

[1] <http://eur-lex.europa.eu/en/index.htm>.
[2] <http://rod.eionet.europa.eu>.
[3] <http://earthtrends.wri.org/text>.
[4] <http://www.grida.no>.
[5] <http://www.unep.org/geo>.
[6] <http://geodata.grid.unep.ch>.
[7] <http://earthwatch.unep.ch/indicators >.
[8] <http://www.un.org/esa/sustdev/natlinfo/indicators>.
[9] <http://mdgs.un.org/unsd/mdg>.

Figure 2: Conceptual framework for environmental security as a combination of 'integrity of ecosystem' and 'human security'



should be achieved within an acceptable *repeat cycle* and trust in the way in which information from the scenes have been constructed and used (*reliability, transparency*). Decision-makers should be able to interpret the analysis outcomes unambiguously. Hence *interpretability, communicability, spatial explicitness,* and clarity about the assumptions on which the findings are based and the uncertainties that surround them (*flexibility/adaptability, credibility, efficiency, simplicity*) should be given. Finally, given the implication that the image analysis process is grounded in the rational and systematic assessment of *evidence*, a desirable characteristic of any outcome is that it should be *robust*, in the sense that it is *repeatable*. Robustness refers to the resilience of the system developed. Given the evidence, any decision-maker should come to the same conclusion—as is assumed, by analogy, in a court of law. This requires that the data on which the model is constructed should be open and available to all who would seek to challenge or test the proposed visions or suggested solutions (*data accessibility*).

A comprehensive database on satellite missions, sensors and application fields (unfortunately only with the status of 2005) is available at the website of the Committee on Earth Observation Satellites (CEOS).[10]

What are the experiences made so far by using remote sensing (RS) and Geographic Information Systems (GIS) for global assessments? In this context, remote sensing and GIS are always used in parallel as the RS data, that is reflectance as a physical parameter, only provide information if combined with complementary spatial data or information.

Soil

The Global Observation of Forest and Land Cover (GOFC) with its Global Observation of Land Dynamics (GOLD) system is a panel of the Global Terrestrial Observing System (GTOS)[11] with an overall objective to improve the quality and availability of observations of forests and land cover at the regional and global scale. Therefore, the aim is to observe, model, analyze, and deliver useful, timely, and validated information on terrestrial ecosystems from satellite datasets useful for soil observations.

It is now recognized that human activity has caused severe degradation of many terrestrial ecosystems and that there have been consequential losses in productive capacity due to soil erosion and desertification processes. Environmental changes, such as desertification, put pressure on social, economic, political, and demographic dynamics triggering insecurity. In order to analyze the state of the art of ecosystem integrity and to manage future impacts from society, conventions underpinned with programs have been developed to acquire sound and up-to-date information on the state of the ecosystems and the processes that sustain them.

However, only recently, a sufficient political momentum has been reached among the member states to develop a proposal for a European Soil Framework Directive (COM, 2006a, p. 232) based on a Soil Thematic Strategy (COM, 2006b, p. 231).

[10] <http://www.eohandbook.com/eohb05/ceos/part3_1.html>

[11] <http://www.fao.org/gtos/gofc-gold>

Parameters to be captured by EO are: Soil types, soil erosion, soil moisture, organic matter content, and soil texture.

Water

Considerable improvements in the assessment of hydrological parameters for water resources management have been made during the last two decades using remote sensing from satellites (UNESCO, 2006; Schultz and Engman, 2000). Using a combination of radar and thermal sensors from weather satellites, the accuracy of precipitation estimates for crop forecasting, flooding, and river flows over large areas and basins has improved considerably, as has the extent of snow cover and water equivalents. In addition, satellite data provide a unique means of assessing separately the actual evaporation over different areas, such as river basins, irrigated areas, and wetlands, using the surface energy balance equation. This has led to methods for determining crop water efficiencies, water use by groundwater irrigation, and wetland water requirements. Another important hydrological parameter that is monitored by active or passive radar is the moisture of the uppermost soil layer (Wagner et.al., 2007).

Important progress has also been made in surveying the land surface. Through the Shuttle Radar Topography Mission (SRTM)[12] a worldwide coverage of digital terrain models, required for example by rainfall-runoff modeling, is now freely available. Satellites through radar altimetry are now surveying water levels in lakes and large rivers within a few centimeters accuracy. This is particularly important for remote water bodies. Satellite images with a resolution of one or two meters can be purchased, making the rapid preparation of maps through digital photogrammetry possible and showing terrain heights of floodplains or coastal areas, which are required to assess flood risks and the propagation of floods. Land subsidence, often due to groundwater extract, can also be measured with high precision by radar interferometry.

Imaging spectrometry (or hyperspectral remote sensing) provides information about the water quality of optically deep-water bodies. The first operational applications from airborne platforms were reported in the 1990s, and the first imaging spectrometry satellites were launched in 2000. The most successfully monitored water quality parameters are chlorophyll, a blue-green (or cyannobacterial) pigment, total suspended matter, vertical light attenuation coefficient, and turbidity. The technique can be used in coastal waters for the assessment of the health of coral reefs and for bathymetric mapping.

Parameters to be captured by EO are: Precipitation, soil moisture, open water bodies including wetlands, and water quality.

Biodiversity of flora and fauna

At the European scale, fundamental achievements have been gained with the implementation of the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC) amalgamated to the Natura 2000 Network and its obligations. Especially the SPIN project[13] and the EON 2000 project funded in the 5th Framework Programme of the European Union, have shown how EO can be used to monitor Special Areas of Conservation (SAC), related to the Habitats Directive and Special Protection Areas (SPAs), which are related to the Birds Directive.

Both projects have developed and tested a coherent spatial indicator system based on multi-sensor satellite data and GIS to accomplish monitoring and management tasks in the context of Natura 2000. Spatially explicit indicators have been derived either directly from imagery or from habitat and land cover maps based on advanced classifications techniques and assessments such as fragmentation, spatial distribution, and neighborhood relations of key habitats.

Furthermore, the European Union has launched a number of specific nature and environmental protection initiatives, all requesting various monitoring efforts with various spatial components. Among them is the GSE Forest Monitoring[14], which is a European Space Agency (ESA)-funded Service Element (GSE), which performs part of the Global Monitoring for Environment and Security (GMES, see below). This program has an applied focus and directly contributes to datasets useful for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1973), the Bern Convention (1979), the United Nations Convention on Biological Diversity (UNCBD) (1992), and others (see Figure 3).

Parameters to be captured by EO are: Vegetation cover, land use, plant health, canopy density, forest species, grassland types, and habitat areas.

Climate and atmosphere

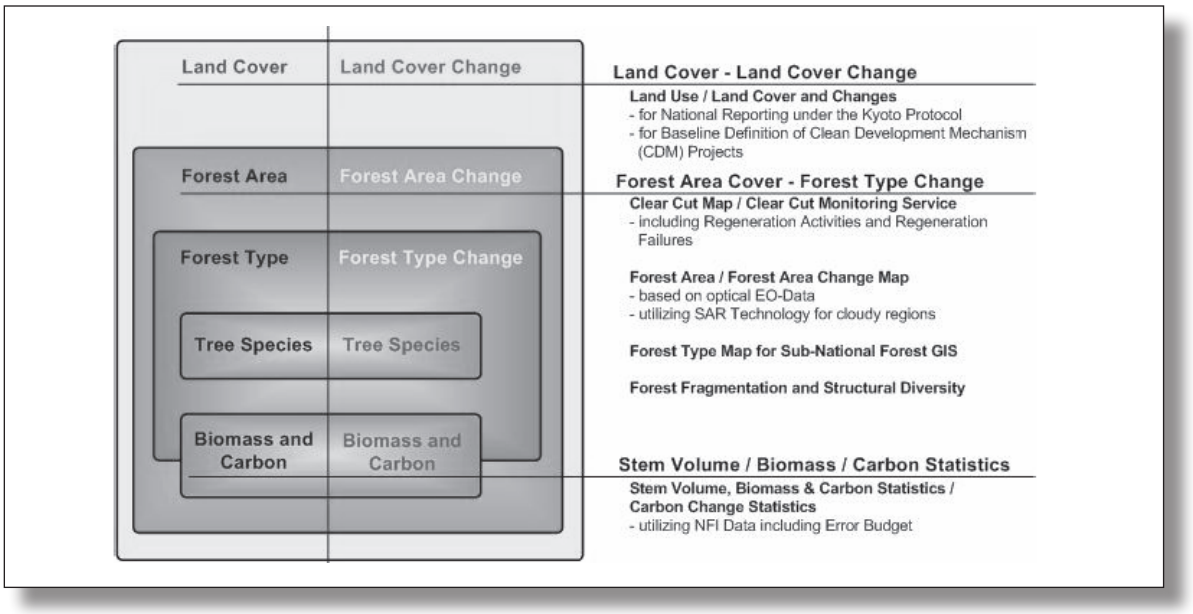
The debate on Global Climate Change (GCC) dates back a few decades. Nowadays, measurements from EO and GIS analysis are able to underpin these ongoing changes and raise human consciousness. Based on the Montreal Protocol (1987) and the United Nations Framework Convention on Climate Change (UNFCCC), an international environmental treaty

[12] <http://srtm.usgs.gov>

[13] <http://www.spin-project.org>

[14] <http://www.gmes-forest.info>

Figure 3: Overview of the Forest Monitoring-related products and services



Source: ESA, 2007

was produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro in 1992. Like the IPCC Directive (1996), the treaty is aimed at reducing greenhouse gas emissions in order to combat global warming specifically addressed in the Kyoto Protocol (1997). For this reason, EO can help monitoring (a) sources and sinks for greenhouse gases, (b) land cover, land use, and land use changes analyzing above-ground vegetation biomass stocks, and (c) afforestation, reforestation, and deforestation measurements necessary to valuate the carbon stock. The latter especially refers to many other regulations such as the Regulation on the Monitoring of Forests (2003) or the Convention on Biological Diversity.

Shifts in chemical composition throughout the lower and upper atmosphere have important implications for terrestrial life and human societies. EO techniques allow for the analysis of atmospheric halogen compounds from the GOME (Global Ozone Monitoring Experiment) instrument aboard the European research satellite ERS-2 using spectroscopic measurements of BrO and OclO, which both show characteristic absorption features in the UV spectral range (Wagner, 1999).

Parameters to be captured by EO are: Temperature, albedo, UV radiation, chemical substances, ozone, clouds, and precipitation.

Conclusion

As documented in the report by UNEP (2001) and indicated in this publication, a set of laws, conventions, and regulations exist and aim for a global analysis of ecosystem integrity. For the different compartments ranging from atmosphere, terrestrial, and aquatic systems to biodiversity of flora and fauna, we have demonstrated that EO and GIS can play a significant role in analyzing and monitoring the earth surface. Confirmed by several publications, we have shown that satellite image data is comparable, remotely taken, verifiable, continuous, and spatially explicit and hence have a great capability to address the objectives stated in the treaties mentioned.

However, there are also some challenges among all the advantages pointed out. According to some investigations, technical restrictions in spatial, temporal, and spectral resolution have their limitations. Despite the fact that (with recently launched satellites) the spatial resolution is increasing, the handling of the volume of data and available computing capabilities are limiting factors. It is assumed that 80 percent of the images taken remain without analysis. The revisit period of a satellite on a sun synchronous orbit has a natural gap of a couple of days. More satellites with comparable sensor specifications can reduce the time span between observations. To improve the situation, the European Space Agency (ESA) has started several studies on interoperability aspects to harmonize the ESA and third party mission heritage ground segments. On the interoperability projects, the "Heterogeneous Mission Access" (HMA) study—initiated in mid-2005—

combines the major European national mission operators in order to identify and prototype a protocol for the interoperable access to their mission catalogs and archives (Schreier, 2006).

Other limiting factors are the costs and often restricted access (due to political concerns) to very high resolution imageries (VHR) that hinder a more detailed investigation of the earth ecosystems. As some of the VHR sensors are now operated on a commercial basis, access can be improved, especially if the open-sky policies are adhered to by national governments (shutter control). Availability of scenes from optical sensors also depends on atmospheric conditions such as cloud cover and fog. Finally, data caption and analysis is restricted to the earth surface or at least to the first centimeters of the topsoil.

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COM. See: Commission of the European Communities

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UNCCD. See: United Nations Convention to Combat Desertification

UNEP. See: United Nations Environment Programme.

UNESCO. See: United Nations Educational, Scientific and Cultural Organization.

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Effectiveness of Space-based Civil Remote Sensing Satellites for Treaty Monitoring

Bhupendra Jasani

Introduction

Perceptions of regional and international security changed dramatically as reflected, particularly, in two studies published by the European Union in December 2003 and in 2004 by a Group of Experts on behalf of the United Nations Secretary-General.[1] Between them they identified poverty, infectious disease, terrorism, transnational organized crime, state failure, and proliferation of weapons of mass destruction (WMD) as some of the threats to national and international security. A state is secured when it is free from these threats. On the other hand, two other studies, the 2005 Human Security Report[2] and the 2006 Human Development Report[3] concluded that conflicts within states make up for more than 95 percent of armed conflicts and that 1.8 million children die as a result of unclean water. It is hard to believe that such large-scale devastation can result from, for example, acts of terrorism and warfare fought with conventional weapons. Thus, together with WMD, such weapons will also have to be considered.

In the framework of GMOSS, several specific studies were carried out. One example of these is the verification of arms control treaties. The GMOSS group specifically focused on the problems of verification of two arms control treaties—the 1970 Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Comprehensive Nuclear Test-Ban Treaty (CTBT) that was signed in 1996, but is not in force yet.[4] These two treaties, together with the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction (the 1997 CWC), are perhaps the most important measures that affect national and international security.

However, in this contribution, for the above reasons, conventional weapons are the focus. At least in Europe there is a regional agreement called the 1990 "Treaty on Conventional Armed Forces in Europe" (the 1990 CFE Treaty). Another measure that deals with conventional weapons, is the "Ceasefire and Security Agreement between the Government of the Republic of the Sudan and the Sudan People's Liberation Movement/Sudan People's Liberation Army" signed in 2003. In spite of the essential role that earth observation satellites can play in the verification of these treaties, neither of them have suggested the use of satellites.

With the arms control treaties and confidence-building measures in Africa, the usefulness of space-based remote sensing capabilities are assessed taking Sudan as an example.

Sudan Agreement

Some of the important provisions of the 2003 Sudan Agreement are:

- 1.7: "The Parties shall,…provide and share information and statistics on their troops strength, arms and military equipment and any other relevant information, among themselves and with the UN Peace Support Mission"
- 5: Principles of the Ceasefire:

  The following activities will cease:
- 5.3.1: "Military activities including movement, reconnaissance, reinforcement, recruitment, draft, and military exercises other than those permitted by the Joint Defence Board (JDB). The JDB will inform the UN Peace Support Mission of the permitted current and future activities… ."
- 8: Disengagement:
- 8.5. "The Parties shall provide maps and sketches showing their current dispositions before the declaration of the ceasefire."
- 8.7. "Before the declaration of the ceasefire, the Parties shall present detailed lists of size and location of their force in each area to United Nations Advanced Mission in Sudan (UNAMIS), subject by verification of the Verification and Monitoring Team (VMT) and Joint Military Commission (JMC) Nuba Mountains."
- 8.8. "Notwithstanding 8.7 above, the Parties shall present detailed lists of particulars of all troops to the Ceasefire Joint Military Committee (CJMC) or, pending the formation of the CJMC, to the VMT and JMC/Nuba. The lists shall be verified by the CJMC and/or the VMT and JMC, as the case may be, immediately after the declaration of the ceasefire."
- 15: UN Peace Support Mission:
- 15.3. "International monitoring shall be carried out by UN... ."
- 15.4 For the purpose of monitoring activities related to the ceasefire, the international monitors shall have unrestricted access in accordance with a Status of Force Agreement (SOFA), which shall be concluded with the United Nations as soon as possible. Such SOFA shall contain then provisions agreed to by the Parties with the United Nations immediately following the conclusion of the Comprehensive Peace Agreement.

[1] See European Union, 2003 and United Nations, 2004.

[2] http://www.humansecurityreport.info/

[3] http://hdr.undp.org/hdr2006/pdfs/report/HDR06

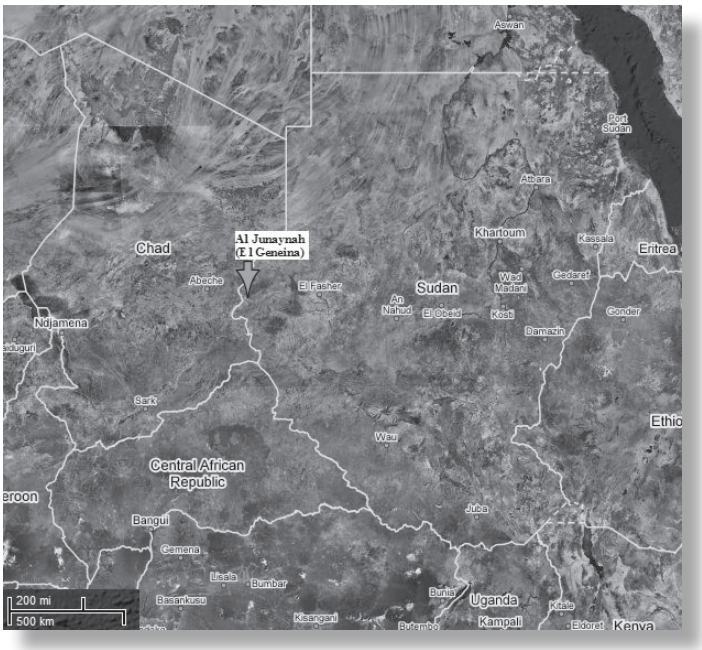
[4] Comprehensive Nuclear Test-Ban Treaty Office, http://www.ctbto.org/

Thus, it can be seen that there are no specific verification methods suggested in the agreement except that the United Nations will have a vital role to play. Moreover, there is a provision for on-site-inspections. However, space-based observations can have an important role in identifying undeclared sites and activities.

Role of space-based remote sensing in monitoring the Sudan Agreement

In this assessment, images acquired by the US QuickBird satellite available from two Google Earth sites over the Internet have been used.[5] Often the images acquired in this way do not have either the full spatial resolution or their technical details. However, they are freely available. These sites are useful for initial studies or for demonstration. Original images could then be purchased from the US company, Digital Globe, for a detailed analysis. Consider Al Junaynah near the border of Chad and Sudan. Images acquired at two different times over Al Junaynah were downloaded. The date of the first one is not known and the second one was acquired some time in 2007. An overview from the earlier image is shown in Figure 1.

Figure 1: General overview of Al Junaynah (date unknown)

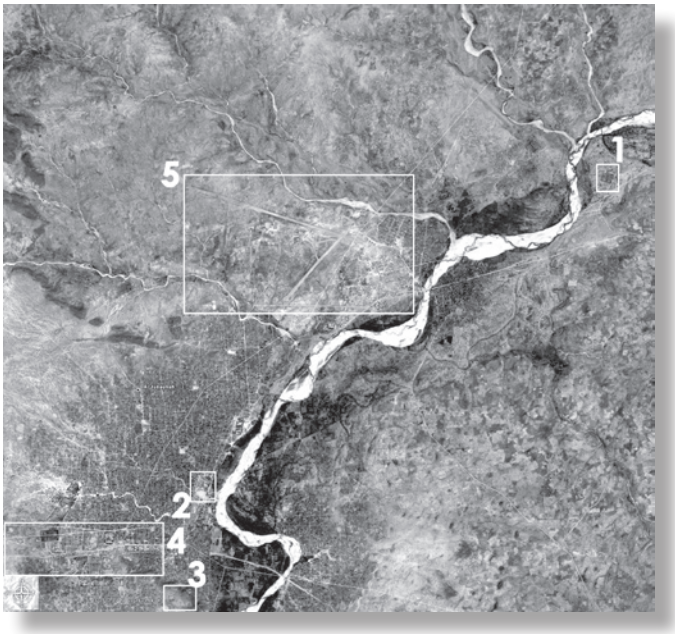


Source: Digital Globe, QuickBird satellite; <http://maps.google.com/maps>.

Al Junaynah barracks

From Figure 1, a section over Al Junaynah was enlarged and is shown in Figure 2 in which a number of militarily significant sites (Areas **1–5**) were identified. From this, the disposition of troops and military equipment, as required by paragraph 8.5 of the Sudan Agreement, can be determined. A possible troop and vehicle deployment area at **4** and a large military airfield (Geneina Airfield) at **5** were analyzed in order to determine whether these were active or not from observing changes in the sites over a period between the first image and the one that was acquired in 2007. From such images, troop strength could also be estimated as required by Paragraph 1.7 of the Sudan Agreement.

Figure 2: Enlarged section of the general overview of Al Junaynah



Source: Digital Globe, QuickBird satellite; http://maps.google.com/maps; Scale: 1:80,000

In the extract above from the Al Junaynah area near the Chad border, a number of activities were detected (Areas **1–5**). At **4**, a possible troop and vehicle deployment area with vehicle storage and barracks was identified. Considerable developments in the vehicle storage area (**A**) and in the military barrack (**B**) can be seen in Figure 3, when the images, which were taken at different times, are compared. This shows that there is no reduction in troops, but quite the opposite.

[5] <http://www.google.co.uk/ and http://maps.google.com/maps>

Figure 3: Comparison of vehicle storage and barracks before 2007 and during 2007

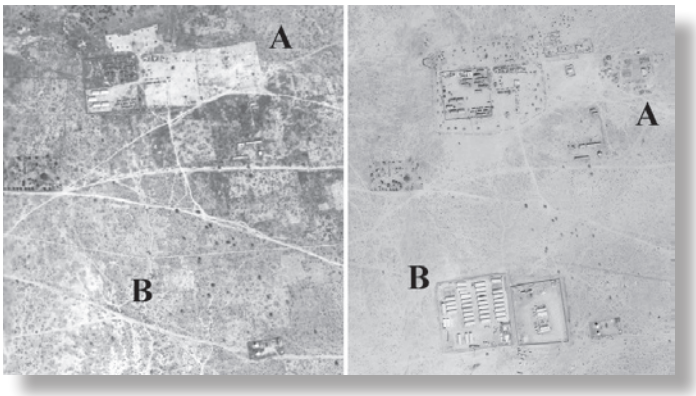
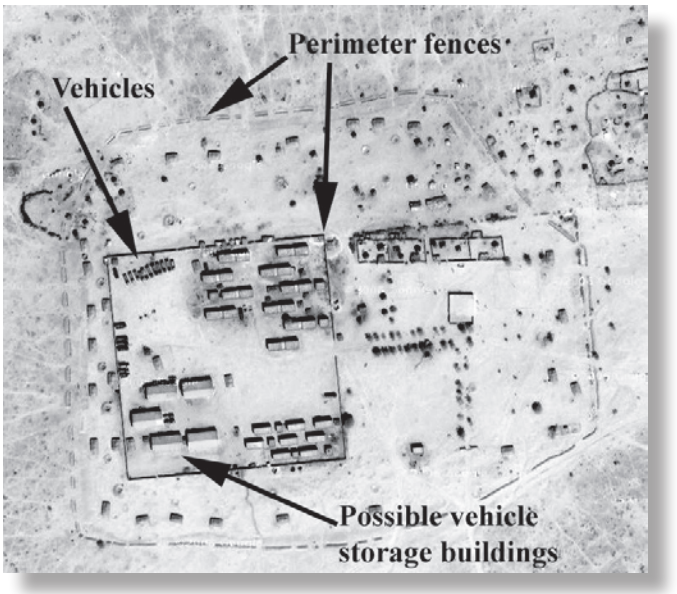


Image acquired before 2007 | Image acquired during 2007; Scale: 1:1,300

Enlarged sections of area **4** from Figure 2 show the development in the possible vehicle storage area (**A**) and barracks area (**B**) over the period between the acquisitions of the two images.

Figure 4: Enlarged section of the vehicle storage area from the 2007 image.



From the scale of the image in Figure 3, the sizes of the barracks at **B** in the right hand image were determined. Each building is about 32m x 10m giving an area of 320m^2. Assuming that each soldier might occupy an area of about 9m^2 (one bed, a small side table, and a locker), the number of soldiers in each barrack was estimated at 35 per barrack. There are 34 barracks so that there might be about 1,200 soldiers at this site. Thus, these could be compared with the declared troop strengths.

Geneina Airfield

The Geneina Airfield is located to the north-east of Al Junaynah. It is shown in Figure 5. For comparison, the image acquired before 2007 and one during 2007 are shown side by side. Several more aircraft and helicopters can be detected in the central region **A** of the image acquired during 2007. Also there are areas where development is taking place as indicated by differences in the two images.

Figure 5: Geneina Airfield

The images of Geneina Airfield before 2007 (left image) and during 2007 show considerable differences at **A**, indicating that the airfield is very active.

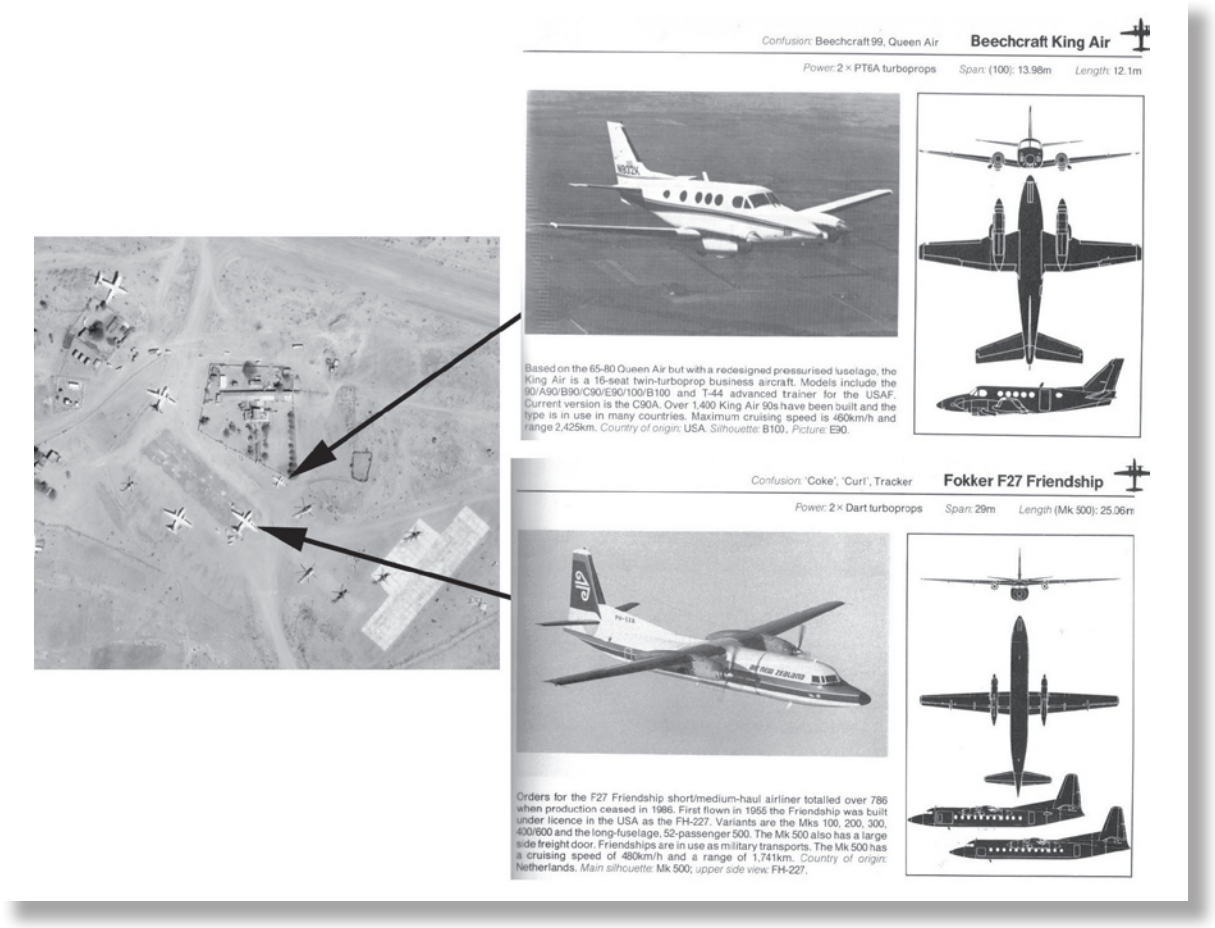
Using Jane's *World Aircraft Recognition Handbook* (Wood, 1992), it was possible to identify various aircraft. This is illustrated in Figure 6 in which an example of the identification of two aircraft is shown. Knowing the scale of the image acquired from the satellite, the shapes and the sizes of aircraft were matched with those given in the Jane's publication and then compared with the line drawings given in the Jane's book. As the scales and dimensions of the aircraft drawings are given in the Jane's, it would also be possible to carry out the identification automatically by computer.

From the above analysis, it can be seen that it is possible to quantify the military strength from satellite remote sensing.

Conclusion

Considerable progress has been made so far in the development of sensors based on earth orbiting satellites. Spatial resolution of space-based sensors has improved to such an extent that it is possible, and even feasible, to identify small military vehicles and aircraft. It is also possible to determine the military strength and deployment mode of an adversary. The image interpretation task is also becoming relatively easier as for many military equipment and defense-related buildings, a so-called 'key' has been developed. For example, under the treaty monitoring activities, the following areas have progressed well:

Figure 6: Enlargement of a section of the Geneina Airfield—Line drawings in Jane's



Source: Wood, 1992.

Note: An enlarged section of the Geneina Airfield showing a number of aircraft and helicopters stationed on the parking apron.

- Various types of targets have been studied using commercial satellite imageries;
- It was possible to build up typical signatures for such targets;
- The work on signature identification and application of remote sensing to other treaties, including peace treaties is also being developed;
- Development in software is also continuing so as to detect targets automatically in a scene using computers and the above worked out signatures; and
- Considerable amount of progress has been made in the area of detection of changes in an image.

Thus, the above analysis indicates that an arms control treaty or confidence-building measures involving conventional weapons could be monitored. The technique could also be very useful to give early warnings, for example of an impending military threat.

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Challenges in Treaty Monitoring

Irmgard Niemeyer

Introduction

In the last decades, the international community has signed several international treaties and conventions, such as Multilateral Environmental Agreements (MEA). These agreements[1] oblige parties to (in)directly, and to a different extent, implement procedures to monitor and assess the environment on a regular basis and report their efforts to combat environmental degradation. Aschbacher (2002), Arino et al. (2003) and Peter (2003) provide overviews on using Earth Observation (EO) data for MEA monitoring.

Furthermore, a number of international agreements and export control regimes have been concluded in order to reduce the risk and proliferation of arms and particularly weapons of mass destruction. The objectives of these agreements are to reduce or eliminate certain weapons or weapons systems, and to curb the proliferation of weapons as well as sensitive dual-use technologies, or to increase security and build confidence in other ways.[2]

Different conventions imply different obligations and implementation practices for the parties. However, EO generally represents a key source of information for the different national and international bodies involved in the implementation of international agreements. If the area of interest is not accessible on the ground, remote sensing sensors represent one of the few opportunities to gather almost real-time data over the area.

EO technology may assist significantly in the achievement of the objectives of MEA by increasing scientific and technical knowledge about the environment, supporting the efficient management of environmental problems, and contributing to improved and better performance of the agreement (Arino et al., 2003).

For arms control and non-proliferation treaties, such as the Nuclear Non-Proliferation Treaty (NPT), the main applications of satellite imagery are to verify the correctness and completeness of the member states' declarations and to provide preparatory information for on-site inspections and other technical visits.

Taking into consideration recent developments in satellite sensor technologies and software solutions, this contribution discusses some challenges with regard to political and technical issues. First, earth observation policies and data availability will be presented. Then, the potential of satellite imagery information and digital image processing will be explored. Following this, parameters measurable from space for verification purposes will be presented. Lastly, the contribution closes with some reflections on confidence-building, verification responsibilities, and capacities.

Earth observation policies

Is the space an 'open space'?

Following the launch of the first civilian remote sensing satellite in 1972, some developing countries demanded a special regulation on remote sensing in 1978. They were concerned that remote sensing satellites make it possible to gather information on mineral resources, weather and climatic changes, and resources management.

The Principles Relating to Remote Sensing of the Earth from Space adopted in UN resolution 41/54 in 1986 confirmed the unrestricted right to remote sensing without prior consent or notification. In return, the state subject to remote sensing has access to the data on a non-discriminatory basis and at a reasonable price. The Principles do not apply to military reconnaissance.

Data availability from space

Among the optical very-high resolution systems, four privately-funded systems are in orbit. Three are owned by US companies and the other is owned by an Israeli company. Very high-resolution optical and high-resolution SAR satellites are under operation or being developed by national space agencies and, partly as public-private-partnerships, in Canada, France, Germany, Italy, India, Russia, and South Korea.

In general, satellite image data is freely available, unless it is a risk to national security. A restriction on this type of data is called 'shutter control' (cf. p. 45). One example for such 'shutter control' is the restriction of satellite imagery over Israel to a spatial resolution of two meters.

Earth observation systems have different regulations regarding image data. For example, the European satellites as part of the EU/ESA-funded initiative 'Global Monitoring for Environment and Security' (GMES) imply dual-use of the data. How the data will be shared between military and civilian users has not yet been decided. Other systems like the Indian Cartosat-2, do not offer image data on a commercial basis yet.

Furthermore, priority customers may exclude other customers from buying images of certain areas. For example, during the war of 2001, the US government, a priority customer, exclusively bought all imagery acquired over Afghanistan.

[1] For a definiton of agreements and treaties, see p. 53ff of this *brief*.

[2] For more information, see Poucet, 2006.

The high prices for acquiring commercial satellite imagery may also limit the utilization of earth observation data. However, quantity buyers, such as international organizations or national agencies, may have the possibility to conclude a special agreement with the data providers including data access from the database archive or on-demand acquisition within a few days after order placement.

Parameters measurable from space for verification purposes

Depending on the spatial resolution of the satellite data and the nature of the treaty, main information required for treaties can be derived from satellite data. De Sherbinin and Giri (2001) provide a summary for coarse spatial resolution (1 km–16 km), medium spatial resolution (30 m–500 m), and high spatial resolution (1 m–30 m).

EO data from both optical and SAR sensors are available to support the requirements of the Kyoto Protocol on a long-term basis. Remote sensing imagery could be applied to support the implementation of the Protocol in the following areas (Rosenquist et al., 2003):

- Provision of systematic observations of relevant land cover (Articles 5 and 10);
- Support of the establishment of a 1990 carbon stock baseline (Article 3);
- Detection and spatial quantification of change in land cover (Articles 3 and 12);
- Quantification of above-ground vegetation biomass stocks and associated changes therein (Articles 3 and 12);
- Mapping and monitoring of certain sources of anthropogenic CH4 (Articles 3, 5, and 10).

The application of optical, thermal and SAR satellite imagery for the verification of the NPT allows us to detect changes of infrastructure and changes of the operational status within the facility in neighborhood areas. In addition, EO data provides preparatory information for an overview of the facility and its surroundings.

Digital image processing

Computer-based techniques are essential for the pre-processing and analysis of all types of satellite data and can be of great value for treaty monitoring. Though a software system will not be able to replace an image analyst completely in the foreseeable future, he/she could benefit from automated pre-processing, object-based image analysis, and image information mining order to detect, analyze and manage significant features of interest.

Pre-processing includes geometric and radiometric correction. Geometric correction is required when using multitemporal or multisensoral datasets acquired over the same area of interest. By means of geometric correction algorithms, the image data can be registered to each other (image-to-image registration) or to a given map projection (georeferencing). Radiometric correction procedures (e.g. atmospheric modeling or radiometric normalization) aim to adjust the surface radiance or reflectance values by removing atmospheric effects (Jensen, 2005).

In a first approximation, computer-driven object-based image analysis is comparable to visual perception. An image interpreter recognizes the shapes, textures, and coherent regions along with the color present within an image and associates meaningful objects and their contextual relations. A similar goal is intended in object-based image analysis, although the complexity and effectiveness of human perception is still superior. Traditional pixel-based image analysis techniques do not take care of the spatial coherence of high resolution imagery. Rather, the use of object features such as scale, compactness, orientation and texture, in addition to spectral characteristics, extends the possibilities of (high resolution) satellite image analysis. Image objects are extracted by segmentation and ideally represent real world objects (Definiens AG, 2007). Statistical feature analysis helps to prepare a ruled-based classification model for assigning the object classes (Marpu et al., 2007). Niemeyer and Nussbaum (2006) and Nussbaum and Menz (2008) presented the application of object-based change detection and classification for verifying NPT compliance.

Working with huge image archives requires a specific database management system (DBMS), rather than analyzing single scenes stored in a specific file directory. The DBMS controls the organization, storage, management, and retrieval of data and information in a database. Usually, the areas of interests are retrieved by doing a query on the metadata, such as coordinates, time of acquisition, sensor type, etc. and processed subsequently. Information given by the metadata may often be less relevant in terms of treaty verification. Particularly for the detection of undeclared or unknown activities, the image analyst may neither know exactly the area of interest nor when the event happend. Thus, approaches for image information mining, including content-based image retrieval and feature extraction (Datcu et al., 2003) show promise also for treaty monitoring.

Confidence-building, improvement of openness, and transparency

Even though the Open Skies Treaty utilizes airborne image data, this Treaty should be exemplified here with respect to confidence-building, openness, and transparency.

The Treaty on Open Skies entered into force on 1 January 2002, and currently has 30 States Parties. The Treaty is designed to enhance mutual understanding and confidence by giving all participants, regardless of size, a direct role in gathering information about military forces and activities of concern to them. The Treaty establishes a regime of unarmed aerial observation flights over the entire territory of its participants. Open Skies is one of the most wide-ranging international efforts to date and it promotes openness and transparency of military forces and activities (Dunay et al., 2004).

Besides improving openness and transparency, cooperative elements, and confidence-building, the principles of Open Skies are to:

- Support the verification of existing or future arms control agreements;
- Strengthen the capacity of conflict prevention and crisis management;
- Permit each member state to observe any point on the territory of the States Parties;
- Allow imagery taken during flights to be accessible to all States Parties.

Verification responsibilities and capacities

Using satellite imagery to verify treaty compliance requires a competent authority provided with a mandate for verification. Satellite imagery must be mentioned in the agreement as a means of verification. Moreover, expertise for processing EO data needs to be available. In this context, the scientific community can provide training and consultancy.

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4 Summary and Recommendations

Summary of the Seminar Discussion

Ruth Vollmer[1]

The following section is largely inspired by and based upon discussion, debate, and dialogue that took place throughout the Seminar. The individual contributions, which were recorded in writing during the Seminar, were summarized, partly restructured, and also streamlined with regard to a number of core questions. Therefore, a number of issues raised within the framework of the Seminar had to be neglected. Furthermore, additional background information was added when considered necessary. This process inevitably is highly subjective in its selection, appraisal, and interpretation.[2]

The topical structure of this section mirrors the structure of the Seminar and underscores the most important issues raised. Reading the related contributions as a background first might be helpful to better understand this section.

Approaches to security, environment, and conflict

The discussion, which followed the general introduction of the security topic, revolved mainly around one definition of security presented, namely "a low probability of damage to acquired values" (Baldwin, 1997, p. 13).[3] It was emphasized that security can only be talked about in *relative* terms and never as something absolute (as "*low probability* of damage" also implies). It was also emphasized that its definition is highly dependent on individual and collective perceptions. People are very likely to perceive low-probability, high impact-events as threats to security. Take the example of the unlikely event of a nuclear war against the United States, which people tend to be more afraid of than of likely events, such as car accidents. Furthermore, if security threats are a matter of perception, then the same is also true for counter measures. One example given was the possession of firearms by citizens of the United States, who thereby expect to have increased safety.

The second part of the definition "acquired values", was disputed in two different respects. First, it was questioned: Are values acquired at all? Second: Is it realistic to speak about a relationship between security and values? If security (at least a core/basic concept of security) is all about physical integrity, would it be better conceptualized as a biological reflex based on human needs? A too 'philosophical' debate about security might be misleading because it merely captures a very high and abstract level of depersonalized and 'weak' security issues. This would be less fundamental and less relevant to the individual. Most participants, however, seemed hardly convinced by this argument. A threat to ecosystem integrity could be seen as an abstract and depersonalized security threat (as opposed to being held at gunpoint for example). Nevertheless, it still turns out to be crucial for human survival (although perceptions about this might differ). Values, such as dignity, were generally conceived to be relevant by most, as they can play a role in the emergence of conflict and thus have to be considered when searching for conflict solutions.

Furthermore, some emphasis was put on the need to distance the concept of security from its traditional militaristic connotations, as recent initiatives and reports by the United Nations do.

With regard to *securitization*[4], the participants pointed out that further research is needed on the specific conditions and factors contributing to securitization, such as what actors need to be involved, how are securitization moves related to access to funding and resources, how can the consideration of ethic/normative deliberations in securitized areas be increased, etc. (see discussion on security strategies below).

Finally, it was argued that an integrated approach to security is necessary. An either-or perspective, which strictly separates security as a social object or social construction (essential vs. statutory definition) may be misleading or even dangerous, because security-related events occur independently of being defined as such; one example given was the violent conflict in Darfur.

In the discussion on the securitization of environment or the *'greening' of security policies* as reflected in a number of recent national and international security strategies (see contribution by Meyer-Ohlendorf, p. 17ff), the key contextual factors, which have an impact on these received the most attention. They are summarized here in three major categories, some of which pose more questions than provide answers.

Actors

Which (groups of) actors drive the debate?

What different institutional interests, value systems, etc. do they represent?

Are there regional differences in the backgrounds of main players and if so, do they affect the opinions they put forward or roles they play?

How would regional differences influence political agendas, the contents and the implementation of security strategies?

[1] The author would like to thank Peter Zeil and Wim Zwijnenburg for their very helpful comments on an earlier version of this text and Heike Webb for her support in writing the minutes of the discussion.

[2] It also raises questions of authorship and intellectual property rights, which could not entirely be solved. The only solution found is to emphasize that this part of the publication displays thoughts and ideas raised and discussed by all participants of the seminar (see list in the Annex) including Peter Zeil and Lars Wirkus, who facilitated the discussion and summarized its results.

[3] See contribution by von Boemcken, p. 13ff for full reference.

[4] The term *securitization* comes from a constructivist theory of international relations developed by the Copenhagen School, see e.g., Buzan et al., 1998 for details.

How do different relevant groups of actors communicate? That is, do they speak a 'common language'? Does communication take place at all?

How are their roles defined? Who has the lead? Are there explicit agreements on this?

How are outcomes fed into the political process?

Attitudes

In more general terms, the attitudes of all societal groups are important, especially attitudes towards economic commodities and mechanisms, because in traditional economics, environment has no value beyond its exploitation. As this concept is highly unsustainable and a threat to people's livelihoods, it needs to be improved and redefined. It was suggested that pricing ecological services might be one step into this direction.

Legal framework

The core question regarding legislation is: Is there coherence between the different legislative levels (international, national, and local) and the different areas of legislation i.e., security and environment, in terms of the regulations themselves as well as their implementation? As the presentation showed, there are gaps, for example, between international environmental conventions and national security legislation. Overcoming such gaps refers back to the different groups of actors and their (non-)interactions. A positive example mentioned in this context is the European Neighbourhood Policy (ENP) and the national country strategy papers, which address both security and environment among other issues. The OSCE Environmental Security Strategy (not adopted yet) could have the potential to increase policy coherence between state actors and different political sectors once it has entered into force.

In addition to all these open questions, no final conclusion could be reached on the following issue: Is the connection made between environment and security merely a social construction? If so, the aim of certain groups—the 'securitizing actors'—could be *inter alia* to place the environment higher on the political agenda as to increase financial support for development- and environment-related projects. Nevertheless, they may be triggering policy measures that run contrary to their initial concerns. Or—and this is the counter position—is the environment a real security issue which, in the face of global environmental change, is slowly starting to receive the attention it deserves?

Environmental security- and conflict risk assessments

The main question which emerged during the discussion about resources, conflict, and governance (see contribution by Wirkus and Schure, p. 20ff) was: What actually constitutes good resource governance? This is related to the observation that governance may be the crucial factor for (man-made) resource scarcity, unjust allocation of resources, and related conflict (de-)escalation processes, as pointed out by Wirkus and Schure. Effectiveness is certainly no criterion, as effective resource governance does not necessarily reduce the likeliness of conflict. It can, on the contrary, be a precondition for war, since resources as well as revenues from resource sales can be used to finance and maintain conflicts.

It was agreed that there cannot be a blueprint for good resource governance. Recommendations for good resource governance were specifically tailoring it to the local situation and bringing it in coherence with other political sectors. Besides an environmentally and socially sound management of the resource extraction process, good resource governance should also include a responsible and transparent use of revenues and the improvement of relevant international regimes. The major challenge in their improvement and the implementation of existing agreements is, however, the creation of win-win-situations.

Good resource governance and the implementation of related legislation are thus inextricably linked to the interests and roles of actors and stakeholders. In this respect, multinational enterprises may sometimes have a greater impact than state governments through their role in resource extraction, especially under conditions of fragile statehood, which is problematic for merely all policy-oriented approaches to resource governance. Therefore, an all encompassing approach, including the private sector is necessary.[5]

The growing influence of China in the resource sector, especially in Africa, was also discussed. It was agreed that much more research on its role and about the debate on it is needed. Civil society actors who play a crucial role in pushing for better and more transparent resource governance, such as the Fatal Transactions campaign[6] report that Chinese corporations seem less or even not at all susceptible to public pressure. A general lack of transparency and the hiring of private security firms make it almost impossible to gather sufficient information for campaigning.

[5] This is reflected in current initiatives such as the Extractive Industries Transparency Initiative (EITI), <http://eitransparency.org/>.

[6] <http://www.fataltransactions.org/>.

When looking at the conflict relevance of resources and the environment, one has to analyze these two aspects separately (although there can be strong links between them). An example for such links is the case of Darfur, Sudan, where good resource governance is lacking. This consequently has highly adverse effects on the environment and people's livelihoods. However, examples of conflicts related to natural (non-renewable) resources are very concrete, whereas the presumed relation between environment and conflict is a much more complex one.

In the framework of environment and conflict, the participants also paid attention to the often quoted example of water resources. Notwithstanding the thesis of upcoming water wars that dominated public/scientific opinion in the last decades, they endorsed the mostly cooperative character of shared water resources, which was then further exemplified in the case of Iran. Iran was presented as a country with rich experience in the conflict-free allocation and management of scarce water resources and good international water cooperation. Iran was able to set up an Integrated Water Resources Management Plan by 2005 and established national cooperative structures for water management, including representatives from different ministries. It also approached neighboring countries, like Afghanistan and Turkmenistan, to set up comprehensive cooperation activities, which yielded positive and stabilizing results beyond the water sector and included, for example, joint trainings for engineers.

However, it was pointed out that in other countries and regions, which only recently have started to encounter water scarcity as a consequence of economic and demographic development and/or climate change, it may be more difficult to create a peaceful resolution for conflicts possibly resulting from this. (On water and conflict, see contribution by Wirkus and Bogardi, p. 28ff).

The multidisciplinary approach to Environmental Security Assessments applied by the Institute of Environmental Security (IES) (see contribution by Hyde Hecker, p. 35ff) and the concluding question put forward, whether there were any corporations, which apply Geographic Information Systems (GIS) on a large scale to cooperate with, sparked a discussion on opportunities and limits of the use of GIS and remote sensing in security assessments and potentially for early warning.[7]

It was stated that the early identification of hot spots requires *global* monitoring. However, because of financial and technical limitations, the use of low resolution monitoring as an alert system normally is the only option currently available. It permits to detect general changes, for example when fires break out. However, any details such as the source of the fire, cannot be detected. Basically, the instruments and mechanisms for global monitoring are in place and are being used. The decisive question is however: When is the data significant?

'Calibration' is a crucial factor in providing sound data (see also the discussion in the next section on treaty monitoring). What does calibration do in this context? With calibration, the necessary steps are taken to ensure the accuracy and reliability of the monitoring. Calibration in this context should especially consist of the integration of background information (regional specifics, history, etc.), which actually requires contact points on the ground (although this might be impossible and/or too dangerous), and high-resolution images. In addition, before any kind of reaction to monitored events or changes can take place, models need to be developed on the meaning of these events so that the necessary steps can be taken. This also requires the use of additional sources of information. It was largely agreed that a correct interpretation of images (data) is a permanent difficulty when working with space-based remote sensing (RS). Furthermore, while the points mentioned so far clearly show that RS can be used to detect certain events or changes and can serve as an alert system (which supports reactive action), it must be made very clear that this must not be mistaken by early warning. Global monitoring cannot serve the function of global preventive security assessments whereas RS-based early warning can only be conducted for pre-selected areas given that one can sufficiently draw from other sources of information.

The Institute for Environmental Security (IES) considers GIS and RS to be one of five very distinct elements of problem analysis within its multidisciplinary approach (see contribution by Hyde Hecker, p. 35ff). As there is always the danger of obtaining results that either do not satisfy or are not applied by the end user, the IES found its own way of solving the otherwise difficult task of feeding information into the political process. It issues general recommendations at the end of its analysis and then proceeds by searching for donors (based on an analysis of who is already and who should be involved).

A very different approach to security assessments and early warning is the global conflict risk assessment conducted by the Joint Research Centre (JRC). This discussion revolved mainly around how to choose and validate good indicators of conflict, a difficulty which is also reflected in the presentation of this work in the contribution by Burnley, Buda and Kayitakire, p. 38ff). One way—and possibly the only one way—

[7] 'Early warning' is a very general term that can mean the prediction of a broad range of objectionable events. The early warning systems discussed here are used or could be used to predict natural changes and disasters, and to support disaster management, to set up general security assessments in order to estimate (local) (in-)securities and vulnerabilities or to assess the conflict risks of countries.

of validating select indicators of conflict is by comparing the predictions made with the actual conflict occurrences in the countries observed. Did the predictions come true and were most/all conflicts predicted correctly? This type of validation is a process that may last many years. For the selection of indicators, pragmatic requirements may play a highly important role. Indicators have to be detectable, measurable, and applicable to as many countries as possible. Only when these criteria are fulfilled is the continuity of data and data availability guaranteed over years. All indicators, which are more country and case-specific, such as indicators related to environment and natural resources, are much harder to collect, compare, and monitor over a longer period of time.

The presentation of the FAST data base (see contribution by Krummenacher, p. 43ff) triggered a debate on the political will to invest in early warning and engage in preventive action. Despite some ongoing visible and large-scale international efforts, such as a series of United Nations early warning conferences hosted by Germany and a number of individual projects (one being a BICC research project[8]), some participants expressed their general concern stating that it seemed like governments may or have already withdrawn early warning efforts from funding, although they are a precondition for early action. It was emphasized that information-gathering and -sharing in this field would be very helpful in international cooperation and assist its effectiveness. Nonetheless, there seems to be a trend towards conflict-, and especially post-conflict-related activities, which deliver more palpable and tangible results in shorter periods of time and cover more newsworthy topics as opposed to early warning and early action, where ideally 'nothing ever happens'.

FAST[9] was a long-term project conducted by the GMOSS member swisspeace, which aimed at developing a quantitative tool for forecasting and bridging the gap between early warning and early action by comparing structural and event data. A number of select countries (based on the priorities of various development agencies) were monitored over a long period of time. Certain events, which were reported by local informants and international experts, were stored and used as a basis for prognoses on the likelihood of conflict. Thus, FAST contributed to the ongoing scientific debate on early warning indicators (see above) and also solved the problem of information-gathering in an innovative but also debated manner.[10]

Treaty monitoring based on Geographic Information Systems and Remote Sensing

The third part of the seminar was about the application of remote sensing in monitoring multilateral treaties and agreements (RS).[11] This application has a certain tradition and is more manageable than early warning applications. Concrete examples have been provided in the monitoring of humanitarian (contribution by Schneiderbauer, pp. 47ff), environmental (contribution by Zeil, Klug and Niemeyer, p. 53ff), and (dis-)armament treaties (contribution by Jasani, p. 60ff). Presentations and the discussion also focused on more general aspects of it.

The discussion in this part revolved mostly around four main areas:

Opportunities and disadvantages of a focus on treaties: While treaties and agreements are generally perceived positively, some participants expressed their skepticism of them by pointing out that treaties are not necessarily implemented automatically after their ratification. Instead, their implementation depends strongly on national (security) interests. As this can also be used as an argument in favor of treaty monitoring, it was then pointed out in the discussion that the scope of treaties is generally limited i.e. they are often not signed or cannot be signed by non-state and transnational actors. Therefore, the treaties are not binding to them, despite the fact that their roles may be as important as governments' in terms of (non-)compliance. For example, the effectiveness of the Non-Proliferation-Treaty (NPT) is questionable, as it has not stopped the proliferation of nuclear weapons. Although the Comprehensive Test Ban Treaty (CTBT) (not yet in force) has already been considered meaningless and ineffective by some, monitoring opportunities for it have nonetheless been already evaluated. Thus, there are attempts in the field of treaty monitoring, to make it as effective as possible.

In addition, participants pointed out that it would be wrong to constrain monitoring activities to areas covered by existing international treaties. Due to their broad circulation and frequent use, the monitoring of conventional weapons was considered a necessity, which should thus be carried out independent of the question, whether or not a country is party to disarmament treaties.

[8] See von Boemcken and Krieger, 2006 (German only).

[9] To add to the debate about early warning activities: FAST was put to an end by force in early 2008 as the main sponsors canceled their funding.

[10] Debated insofar as local informants can be regarded as potentially biased, but are still a far better source of information than, for example, news agencies, which have often less information and are much more distant to the events.

[11] See pp. 53–54 for definitions.

Different RS approaches to different treaties are necessary: The contributions to this *brief* as well as the discussion highlight that the various areas covered by treaties and the specific questions which are being followed up both require different types of satellite imagery (provided that monitoring is an option at all).

In this context, the spatial resolution of the images plays a role. In general, for example to monitor humanitarian agreements, one needs high-resolution data whereas environmental change can mostly be monitored with lower resolution data. Low-resolution data or images, which are standard for most civilian satellites can, for example, be used to locate bigger bush and forest fires, to estimate their size and temperatures, and also to trace volcanic eruptions. An option, which contributes to more comprehensive monitoring activities by making RS independent of daylight, is the comparison of night-time data used for instance during the Israel / Lebanon crisis or for a damage assessment of the Kashmir earthquake. This type of monitoring draws conclusions from the amount of lights visible in combination with population distribution maps.

To monitor military activities, refugee camps (change detection in terms of density and number), borders, air pollution, and aerosols, medium- and high-resolution data is necessary. These types of monitoring make use of morphological data processing and automatic change detection. However, no matter how high the resolution of images is, one can count tents but not (mostly) their inhabitants, even though one can estimate the most likely number by taking the average.

Radar images can be used along with different available degrees of spatial (and also temporal) resolutions. This makes RS basically independent of daylight and weather conditions. There are three major restrictions on the use of radar satellites. First, time coverage, even though Italy and Germany have just launched new radar satellites, second, the necessity of much more transformation of the data, third, disturbances to radar beams by natural phenomena, such as turbulences on water.

Opportunities and limitations of RS[12]: One advantage of satellite images is that they are verifiable and almost constantly available. Another advantage is that very high-resolution commercial satellites today offer data with unprecedented quality and provide coverage (mostly) unaffected by shutter control (although access to these images is a matter of costs).

A disadvantage, however, is that remote sensing is by far not sufficient enough to give an adequate impression of what is actually happening on the ground. RS provides very limited information on how to evaluate monitored events. RS data can still be an indispensable element of such assessments; when access to the location is denied (for example, for security reasons), all other possible sources of information must be used to assess the situation. This requires a decision on additional data or information, which should be used in (remote sensing-based) assessments. This in turn is relevant *inter alia* for the choice between different options in image processing, such as preprocessing or classic visual interpretation, because the latter permits an integration of socio-economic models.

The indirectness of remote sensing raises questions on the objectivity of the information it provides. Does the type of the instrument determine the outcome i.e., the information provided by the satellite image? It was mentioned before that low resolution images can be used for global monitoring. In contrast, high resolution images can only be used for particular tasks or in particular areas as their use is limited, for example, by the availability of funds. Applications are hence predetermined by political developments, requirements, media coverage or reports from the ground. Representatives of the RS-community at the seminar admitted that this is indeed a constraint, as it is a very general scientific problem that theories and instruments used might determine the kinds of results delivered. Potentially, all approaches i.e. all the decisions (on the region, methodology, relevant indicators, specific research aims, etc.) made before obtaining satellite imagery of a location have a more or less strong impact on the results. Perhaps the only way of dealing with this fundamental problem is to provide the highest degree of transparency possible with regard to tools, methodologies, sources, and capacities.

One potential flaw in remote sensing is that certain events or areas might be monitored just because they *can* be monitored, independent of their actual relevance while others, which might be relevant *cannot* be monitored. So possibly, estimations of troop numbers based on the number of military vehicles or the size of buildings might be rather irrelevant in times of asymmetrical warfare. In addition, the availability of descriptions of conventional weapons and aircraft might further invite one-sided approaches. Refugee camps and rural settlements are already far more difficult to monitor and if foot soldiers and equipment in particular are 'hidden' in urban areas, they are principally undetectable.

The relevance of such observations for environmental applications is that while the ecological breakdown of a lake for example can be monitored, the causal factors for it are far less obvious.

Another aspect, which further curtails the use of remote sensing in treaty monitoring is that particular countries may be trying to avoid being monitored. For example in the past, Iran moved its nuclear facilities in Natans

[12] Despite this section's focus on treaty monitoring, advantages and disadvantages listed here are also relevant in more general terms.

underground, which made NPT-verification by means of earth observation difficult. This inherent problem of RS results in the fact that military hardware is increasingly protected in bunkers or hidden otherwise.

Legal questions concerning the collection and use of images: The use of satellite images to support claims of human rights violations committed by national governments has triggered debates about the validity and the legal implications of such evidence. Although for example, the "UN Principles relating to remote sensing of the earth from space" (A/RES/41/65 of 1986) allow and encourage the use of EO for security purposes ("for the benefit and in the interest of all countries"),[13] a number of countries keep questioning the legitimacy of the use of such images. A discussion on the modalities of how to implement the rights and obligations linked with these regulations is thus another challenge (see also contribution by Niemeyer, p. 64ff). This also partly relates to the fact that there are only a restricted number of satellites and most of them belong to national governments. Attempts in the private sector to catch up on this are very recent.

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Suggestions for a Future Agenda for Research and Practice

Ruth Vollmer, Lars Wirkus and Peter Zeil[1]

In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels.

Agenda 21, Chapter 40.1[2]

Based on what has been stated in this BICC *brief* and on a short review of some initiatives and literature on the topic, the last section aims to answer the initial questions outlined in the Introduction. In doing so, it attempts to bridge a number of very different aspects, identify current shortcomings and present some examples of good practices as a possible orientation for future action. A very brief (and surely not comprehensive) state-of-the-art description will be given for at least some of the issues that are touched upon in the following in order to facilitate future research and other activities. After the presentation and contextualization of some implications of the Seminar, a short overview of international activities to enhance and coordinate remote sensing activities will be given; after this, further challenges beyond the discussion will be identified.

Central topics to be covered by future research were identified as:

- Statistically relevant research on the proposed causal relation between environment and conflict;
- Conditions for (the success of) securitization moves;
- Identification of indicators and improved scenario development for environmental security assessments and decision-making.

Challenges for practitioners, which resulted from the discussion are:

- Bridge gaps between different stakeholders and communities;
- Integrate stakeholder and end user needs;
- Increase acceptance and efficiency of early warning;
- Tackle legal questions related to civil uses of outer space.

Further challenges can be seen in:

- Capacity-building on all levels;
- International cooperation and dialogue for planning and data sharing;
- Enhancing data accessibility and processing capabilities.

All of these points will now be elaborated upon in some more detail.

Research gaps

Environment, conflict and security

A number of research efforts have been undertaken within the last 30 years in order to gain scientific insight into the proposed environment-conflict nexus. When looking into this research today, one is confronted with a multi-faceted picture. The outcomes of these efforts have been criticized often and particularly on two grounds. Firstly, research has very often been theory-based, rather than empirically oriented and had to face the criticism that it was "motivated by Northern theoretical and strategic interests rather than informed by solid empirical research" (Barnett, 2001, p. 5). Second, many of the empirical studies which have been conducted so far were focused on select countries or regions (qualitative or semi-quantitative studies). They were thus (along with other general methodological concerns) confronted with the criticism that case study selection was biased, taking only countries into account, where environmental degradation and conflict already coincided, thus making it analytically difficult to achieve any findings on causal relations (Gleditsch, 2001). In these cases, results could thus have been predetermined by choosing environmental change or scarcity as independent variable and neglecting the effects of economic and political factors on conflict and on the environment (Hauge and Ellingsen, 2001; Levy, 1995).

Few quantitative empirical studies (see for example the FAST database presented in by Krummenacher, p. 43ff in this *brief*, or Urdal, 2005) have found weak or no evidence at all for a causal link. Hauge and Ellingsen (2001) found some effect of environmental scarcity (supply- and demand-induced scarcity[3]) on conflict likeliness in a large-N study but also concluded that economic and (in most cases) political factors have a greater weight. The State Failure Task Force, which tested the impact of environmental change on political violence as impact on societies depending on vulnerability and mediated by capacities to respond, found no direct relation[4] (Esty et al., 1999). Contradictory evidence, i.e. that environmental change in almost all cases does not lead to conflict, was gathered on the interstate level (Tir and Diehl, 2001, see also the example discussed by Wirkus and Bogardi (p. 28ff in this *brief*). Still, quite a number

[1] The authors would like to thank Joe Farha, Clara Fischer, Jan Grebe, Andrea Warnecke, and Wim Zwijnenburg for their very helpful comments on an earlier draft of this text.

[2] See <www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm> for document text.

[3] Homer-Dixon differentiates between three types of "environmental scarcity": supply-induced scarcity (degradation or depletion of renewable resources), demand-induced scarcity (population growth or increased consumption) and structural scarcity (unequal social distribution) (see Percival and Homer-Dixon, 2001, p. 14).

of authors who conducted in-depth case studies think that the environment should be regarded as a relevant dimension of conflict genesis. One example is the conflict potential of resource extraction projects conducted by big multinational enterprises in developing countries. In such cases the analytical inclusion of the environmental dimension is considered helpful to understand conflict dynamics especially involving enterprises and local communities (Baechler et al., 1996, pp. 167–238; Boege et al., 2006). It seems to come down to what Goldstone (2001) cautioned when he stated that the possibility of a connection is "not the same as showing that there generally will be a connection" (p. 88). Evidence for the latter would be needed in order to predict (and possibly prevent) environment-related conflict occurrence on a global scale.

In most of the case studies mentioned above, the situation is described as a complex bundle of different factors among which 'environmental scarcity' is seen as a background or mediating variable, or more accurately, as a set of background variables. More general approaches see an "indirect and multi-causal" relationship between environment and conflict (NATO CCMS, 1999, p. 43). This might make it more difficult to measure the impact of environment as such (Conca, 2001).

In order to receive a valid and quantitative conclusion on this, it would be necessary to *identify* and *operationalize* relevant environmental as well as socio-economic factors and *analyze* their different possible interactions with each other.[5] Recently it was pointed out that an answer to the "environmental-conflict question" might require the inclusion not only of structural risks but also of psychological factors ("Why do individuals choose violence?") (Barnett and Adger, 2007, p. 649f.).[6]

The lack of data on environment has been found to be a major impediment especially to quantitative empirical research (Hauge and Ellingsen, 2001; Esty et al., 1999; Gleditsch, 2001; Summary). Remote Sensing can be a great help to fill this data gap, at least in certain fields and when accessibility of the data (including a user-friendly format) is guaranteed. In addition, data availability for the sub-country levels would be an asset for the analysis of local conflict dynamics. So there is a need for profound empirical research on the exact nature of the proposed relation between environment and conflict and today's improved data availability actually encourages new attempts.

Securitization

One should carefully consider the consequences of treating environment as a security issue. Given the extensive debate on new threats but also on new approaches to security which yielded a broad variety of different security concepts (see for instance Brauch, 2005 and also briefly the Introduction) which entail different implications for action, it is advisable to define the 'kind' of security one is referring to.

The questions listed in the Summary (p. 69ff) on factors influencing securitization can be used as (initial) frame for more empirical research on the conditions leading or contributing to securitization moves and their outcomes. The year 2007, starting with the first UN Security Council debate on climate change ever,[7] has seen an unprecedented number of publications on the security implications and conflict risks of climate change (e. g., Smith and Vivekananda, 2007; CNA Corporation, 2007; Campbell et al., 2007; German Advisory Council on Global Change, 2008) and thus provides plenty of material for such investigation itself. Despite the very different nature, backgrounds and goals of these reports it can generally be concluded that concrete evidence for the proposed links between environment, conflict and (national) security is often missing (Brzoska, 2008). Some of the studies focus explicitly on national security implications, while others remain vague when it comes to the definition of the underlying security concepts.

Certainly, climate change is a security issue for "certain communities, cultures and countries" (Barnett 2001, p. 2). Some states will loose big parts or even their entire territory to the sea, and traditional lifestyles and knowledge together with the livelihoods of people are already at risk through rapidly changing environments. However, taking into account that securitization may lead to a confrontational rather than solidary approach and might entail security risks itself (see Haldén, 2007) rather than efficient protection measures one should be aware of the possible implications of security discourses. Although the linking of environment and security proved to be a politically successful concept, scientifically it is not clear yet if those two "are mutually supportive or in competition" (Gleditsch, 2001, p. 259). At the same time the question arises for discursive alternatives. One suggestion, which has been brought forward is that of environmental peacemaking and peacebuilding, which is based on the assumption that rather than being a cause for disagreement or

[4] Indirectly, environmental change was found to be related to changes in infant mortality which in turn has been found to be highly correlated with state failure and other socio-economic indicators.

[5] See e.g. the potentially helpful distinction between key variables and contextual factors in Schwartz, Deligiannis, and Homer-Dixon, 2001.

[6] See also Jack Goldstone (2001) on the role of elites in the emergence of conflict. Such factors are of course not only relevant in the debate on environment and conflict but in all types of conflict. However, they frequently tend to be neglected and this gives rise to the impression that environment and climate change act as the drivers of socio-political decisions, which is simply incorrect. See also Haldén (2007, p. 28) on this, who points out that "climate change will not transform political systems" and that "political systems will interpret climate change instead."

[7] See <www.un.org/News/Press/docs/2007/sc9000.doc.htm> for more information.

even violence, environmental change (when met with joint conservation measures) can serve as a trigger for cooperation within and beyond the environmental realm and at all levels (see e.g. Carius, 2007).

Another 2007 report on climate change and security by the Swedish Defence Research Agency (FOI) sees climate change not as a security threat but as a condition, in the framework of which individuals make decisions guided *inter alia* by their institutional interests (Haldén, 2007). This report suggests to use the concept of 'indivisible' security. Indivisible security as opposed to traditional 'zero-sum-game' notions of security emphasizes that security gains in one region or by one group should not be perceived as a loss in security by neighboring states or actors.

In this vein, earth observation can contribute to the reduction of what Conca (2001) has termed "strategic uncertainty" (as opposed to analytical uncertainty i.e. "incomplete understanding of cause-and effect relationships", see above), which he defines as actors having "incomplete information about each other's attributes, preferences and intentions" (p. 230), especially when data collection and management takes place on a cooperative basis. Notwithstanding the fact that both, strategic and analytical uncertainty can and have been used as false pretext for inaction, it can safely be assumed that the reduction of both supports cooperative action.

Indicator development

Space-based monitoring can play an important role for both (quantitative) studies on environment-conflict links and environmental security assessments (which are very likely to be based on a human security concept). It was, however, pointed out earlier in several parts of the publication that the selection and verification of indicators for these purposes poses an enormous (and unresolved) challenge.

Questions deriving from this are *inter alia*: What are the most relevant/significant indicators and variables for environmental security assessments? How can they be monitored and on what scale?

It has been shown in this *brief* that the selection of certain regions is an appropriate approach for (environmental) security assessments, however for global early warning and conflict prevention it is not. Yet, the application of remote sensing faces a number of constraints on this latter, global level (see Summary). What types of monitoring are most helpful to this end? How can satellite data be complemented by additional information? How can scenario development as such and its relevance and reliability for political decision-making be improved?

As to indicator development, one does not have to start from scratch. The United Nations Statistics Division (UNSD) set up a list of environmental indicators and related socio-economic indicators in cooperation with the Inter-governmental Working Group on the Advancement of Environment Statistics in 1995, which was endorsed by the Statistical Commission in the same year and has since been used by the UNSD for compilation.[8] As pointed out in the contribution by Zeil et al., p. 50ff of this *brief,* the United Nations system-wide Earthwatch Mechanism (or Earthwatch), founded in 1972 at the UN Conference on the Human Environment in Stockholm and revived after the 1992 UN Conference on Environment and Development in Rio de Janeiro has the aim to "coordinate, harmonize and catalyze environmental observation activities among all UN agencies for integrated assessment purposes"[9] and is basically a service provided by UNEP to the entire UN system. Hence some suggestions and experience already exist for orientation, which can be used, tested and enhanced. The major difficulty in this regard will be to develop indicators (and collect corresponding data), which capture vulnerability to environmental change rather than just environmental change or scarcity (cf. similarly Esty et al., 1999 on the lack of data on coping capacities). In this context, it needs to be underlined that vulnerability is everything but a clear cut and well-defined concept with definitions ranging from the core notion of vulnerability as an internal risk factor to very broad ones of multidimensional vulnerability (Birkmann and Wisner, 2006, p. 11). Traditionally, the term vulnerability has been used in the context of natural and man-made disasters (see, for instance Schneiderbauer, 2007) but also with reference to climate change impacts (exemplified by the 1998 IPCC report; Brauch, 2005, p. 31ff).[10] This makes it even harder to find appropriate ways of measuring vulnerabilities and the capacities to adapt or respond to environmental impacts (Birkmann and Wisner, 2006).

Two initiatives are currently conducting environmental security assessments for selected regions. These are the Environment and Security Initiative (ENVSEC) with a regional focus on Central Asia, Caucasus and Southern and Eastern Europe[11], and the IES which has developed and is currently testing a related but slightly different

[8] See <http://unstats.un.org/unsd/environment/indicators.htm> for this list. An overview of the various indicators set up by United Nations Organizations in the past is given here: <http://earthwatch.unep.net/indicators/un/index.php> (accessed March 2008).

[9] See <http://earthwatch.unep.ch/about/index.php> for mission statement and further details.

[10] Methodologies for general vulnerability assessments have *inter alia* been developed by the Red Cross ("Red Cross Vulnerability and Capacity Assessment") and Action Aid ("Action Aid Participatory Vulnerability Assessment") (see DFID, 2004). Recently, the importance of integrated assessments, i.e. considering systemic elements (communication, transport, organization, knowledge management, finance, governance and livelihoods) for direct and specific assessments has been particularly emphasized (Moench and Dixit, 2007, p. 10).

approach (presented on p. 35ff) in select regions on different continents. Both have in common that they are conducted on a consultative and cooperative basis including local stakeholders and different sources of information and pursue a multidisciplinary approach. However, both of them are specifically tailored to individual cases and the general applicability of their indicators and methods remains to be tested.

General issues for research and practice

Interdisciplinarity

It might seem obvious that such complex research questions and challenges require interdisciplinary cooperation. Hence, the identification of options for interdisciplinary cooperation (general and environment/climate specific) was the second major goal of the seminar.

Although interdisciplinary research and cooperation has been taking place for quite a while now, it is a continuous process and wherever it is not practiced regularly (in terms of the institutions/persons involved as well as in terms of contents) it is still in its infancy. This was noticeable especially with regard to the cooperation between remote sensing experts and social scientists at the seminar. Past cooperation efforts have mostly attempted to bridge disciplines which had a closer link to each other, such as in the framework of so-called Earth System Sciences, a multidisciplinary approach within natural sciences, or UNESCO's Man and Biosphere Programme (MAB) which promotes interdisciplinary research and capacity-building at the interface of humans and ecosystems since the 1970s. The major challenges for joint research were identified at the seminar as the creation of a mutual understanding of certain core issues and concepts (such as environment and security) and the shared conceptualizations or translations of central terms as a precondition for their interoperability. One might add that in order to initiate joint research on a broader scale, experts on satellite imagery should communicate more broadly about the existing technical options and solutions. Social scientists, too, should identify and communicate their needs with respect to this source, the benefits of which they might not always fully be aware of. It was unequivocally conceded that interdisciplinarity is a major asset, when successfully implemented.

The same preconditions apply to joint action on the topics. In this context, (more) equal access of different actors to the ongoing discourses was identified as a necessity. It was argued that this would ideally mean that the environment is treated as a cross-cutting issue. There are, in fact, many 'gaps' between different 'communities', not just between researchers of different disciplinary backgrounds. Equally important is to bridge gaps (very often including different 'languages' and conceptualizations of terms) between stakeholders and interest groups, groups of various professional backgrounds, between theory and practice, between developed and developing countries and not least between providers of satellite applications and decision-makers. A comprehensive discussion on disciplinary borders and multi-stakeholder participation is provided e.g., by Carius and Dabelko (2004).

Implications for practice

A number of implications for practice result from the seminar discussion. The three most central ones are (1) the integration of user needs, (2) early warning applications and (3) legal aspects.

An identification and inclusion of end users and stakeholders is central when intending to use EO information efficiently as decision support. Foghelin (2008) identified criteria that need to be fulfilled to guarantee smooth and helpful support for important and sometimes very urgent decisions through EO data. These are: relevance for the decision-makers, technical quality, quality of data fusion from different sources as well as timing and presentation. Therefore, it might be necessary to start from a regional basis (i.e. GMOSS) to identify needs and institutionalize cooperation. Cooperation with decision-makers could also be used to address the significance of early warning and preventive action and to increase their acceptance and use. The concerns raised in the discussion (see Summary) regarding early warning are *inter alia* supported by an analysis carried out by Levy and Meier (2004), who conclude that in the field of high-quality assessments, which are needed for early warning, there is a severe lack of incentives, necessary data and the testing and advancement of methodologies.

One additional challenge concerns legal aspects and implications (see also contribution by Niemeyer, p. 64ff and Summary). Existing declarations and resolutions are, for example, General Assembly Resolution A/RES/48/192 "Strengthening international cooperation in the monitoring of global environmental problems" of 1993,[12] the Vienna Declaration on Space and Human Development,[13] the UN "Principles Relating to Remote Sensing of the Earth form Outer Space"[14] or the "Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and

[11] For more information, see <www.envsec.org/index.php>.

[12] See <www.un.org/documents/ga/res/48/a48r192.htm> for document text.

[13] Adopted by the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) in July 1999; for more information see <www.un.org/events/unispace3/pressrel/e30pm.htm>.

[14] See <www.un.org/documents/ga/res/41/a41r065.htm> for document text.

in the Interest of All States, Taking into Particular Account the Needs of Developing Countries" (A/RES/51/122).[15] All of these encourage the use and emphasize the role of remote sensing for sustainable development, the achievement of the Millennium Development Goals and in disaster management. However, legal norms are inherently reactive and technological development is, by its very nature, proactive. Ongoing discussions within the legal subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) show that the scale and application areas of remote sensing are not properly represented in international norms.[16]

While "shutter control" (discussed on p. 47ff and p. 64ff) is seen as placing constraints on information rights by some, the lack of regulation might be able to account for some of the skepticism that the use of satellite data is faced with by others. It has, for example, been observed that access to high resolution data is more often restricted than that to low resolution images (Gabrynowicz, 2008). Clearer rules which institutionalize openness of space and define and restrict a number of legitimate exemptions could increase acceptance of remote sensing on the one hand and provide guidance in situations where countries question the correctness or legitimacy of the use of satellite data on their territory on the other.

Global monitoring—Where do we stand?

Remote sensing can play an important role in practice and in research dealing with the relation between environment, security and conflict. The following will provide a brief glance on the emergence, current uses of, and international cooperation in this field.

At present, the technological tools to monitor the earth and its population from space have reached an unprecedented degree of specialization and capacity in terms of scale and data amount. As Deibert (2001) argues, since these capacities exist and technological progress continues rapidly, they should be put to good use by helping to monitor environmental change and provide the necessary data for decision-making and ultimately preventing harmful consequences. However, he also admits that control over these technologies goes along with great power and "will have a strong bearing on the nature and direction of environmental rescue" (Deibert, 2001, p. 268).[17] It should be kept in mind that it was military and intelligence organizations, which provided the purpose and the means for the development of these systems and tended to use the data exclusively for their own demands. The number of new applications and actors and the degree of data accessibility increased markedly after the end of the Cold War and was mostly due to two different factors: growing pressure to multiply the benefits of these technologies created by researchers and international organizations and the search for new purposes and *raison d'être* by the military (particularly in the United States) (see Deibert, 2001 for a discussion of this). It was pointed out at the seminar that space-based monitoring has lost much of its earlier connotation, which linked it almost exclusively to espionage and war.[18] Furthermore, civil earth observation (where GMOSS activities belong) also has an independent history of its own, exemplified by the establishment of the Committee on Earth Observation Satellites (CEOS) in 1984, which coordinated the activities of space agencies in earth remote sensing (Oriol-Pibernat, 2008). Other examples of its applications include the use of earth observation for environmental assessments and resource data bases by UNEP and UNESCO for the purpose of coastal monitoring or biosphere reserves management, including GIS training courses for managers in developing countries.[19]

Such initiatives originated predominantly from within development cooperation, and many actors from this field brought forward the particular need for increased cooperation resulting from the broadened spectrum of applications and the surge of users and providers. Examples for such initiatives are the Decision 9/4 (Information for Decision-making and Participation) of the the ninth session of the Commission on Sustainable Development (CSD9: APRIL 2001), which "urges strengthened cooperation and coordination among global observing systems and research programmes for integrated global observations taking into account, the need for sharing, among all countries, of valuable data such as ground based observation data and satellite remote sensing data"[20] or the Vienna Declaration from 1999 (see footnote 13 above). This document also served to encourage the implementation of the Integrated Global Observing Strategy (IGOS), a partnership mechanism which, on a more institutional level, coordinates monitoring strategies on a thematic

[15] See <www.un.org/documents/ga/res/51/a51r122.htm> for document text.

[16] See <www.unoosa.org/oosa/COPUOS/Legal/2008/symposium.html> (accessed April 2008).

[17] He thereby implicitly states that technology in principle does contribute to an "environmental rescue". Such technological optimism does not meet unambiguous agreement and satellites are far from providing arguments in favor of perceiving them as "green" technology. See for instance, Matthew's (1999, p. 6f.) description of "deep ecologism".

[18] This is of course not due to the fact that satellites today are less frequently used for such purposes but responds to the emergence of other uses and possibly a shift in attention after the end of the Cold War. At least very brief mention should also be made of Critical Surveillance Theory (see e.g., Lyon, 2006) that critically investigates current tendencies towards an omnipresence of surveillance and monitoring. Certainly, environmental conservation measures are not top of the list of criticized activities; however, earth observation uses basically the same mechanisms, and drawing attention to this shall raise awareness of the responsibility connected with it.

[19] See <www0.un.org/events/unispace3/bginfo/activities.htm> for more information.

basis, that is, by promoting a modular approach to monitoring and the harmonization of space-based and *in-situ* observation systems (Oriol-Pibernat, 2008).[21] Among the members are the so-called GxOS consisting of the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) and the Global Ocean Observing System (GOOS). These are three of a number of international programs, which were founded in the early 1990s as a result of growing awareness of global environmental changes that led UN organizations to cooperate with each other to obtain necessary data and making it available to potential users. Others are the Global Atmosphere Watch (GAW), the World Climate Research Programme (WCRP), and the World Climate Data and Monitoring Programme.[22]

The European Commission together with the European Space Agency has set up a mechanism called Global Monitoring for Environmental Security (GMES)[23] (endorsed in 2001), which aims at coordinating existing systems, producing services of guaranteed validity, and ensuring their sustainability. Thus, GMES can bee seen as an umbrella for existing initiatives at the European level, where coordination plays a key role in avoiding unnecessary duplications, fostering the development of new services based on space and *in-situ* data, and developing technology and services to fulfill a set of defined user needs, which are being collected through the involvement of user communities. Efficient data management and information-sharing is a prerequisite for GMES services. In that respect, the INSPIRE (Infrastructure for Spatial Information in Europe) will contribute to facilitating access, use, and harmonization of geospatial information on a pan-European level. Equally, GMES will be key to increase the interoperability of national systems and—by providing a user-base—to foster the development of adequate European standards. Furthermore, it represents the European contribution to GEOSS.

GEOSS (Global Earth Observation System of Systems), coordinated by the Group on Earth Observations (GEO) is meant to be a global umbrella system for earth observation, and all programs and mechanisms mentioned so far are members to it. GEOSS aims at interconnecting "instruments and systems for monitoring and forecasting changes in the global environment"[24] and was founded in 2003 following the calls of both the 2002 World Summit on Sustainable Development and the 2003 G8 Summit for more coordination of earth observation systems. GEOSS places an explicit focus on user involvement (ranging from scientists, engineers and policymakers to governmental and non-governmental organizations among others) and has identified nine core areas or "areas of benefit", which are: disaster management, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity.

Hence, very different actors have made an enormous effort to coordinate their work and increase cooperation on different levels. Of all these initiatives, the European contribution, GMES, is the only one which explicitly links its work to security.

Further challenges ahead

International coordination and cooperation correspond strongly with the hope that remote sensing might help solve a number of global problems and challenges. However, despite this enormous increase in data availability and applications, many of these problems still remain. Three of them, which are directly related to the actual use of space technology, will be briefly discussed here to conclude with and to sketch out a possible direction for future action. These three are:

- actual data availability (for use),
- capacity-building, and
- international cooperation / North-South dialogue.

It has been pointed out that high dependence on ecosystem services, frequent exposure to unforeseen and adverse effects of nature and environmental degradation as well as low coping capacities in general are integral elements of environmental insecurity. And it is obvious that such risks and vulnerabilities are much more likely to involve developing countries and marginalized populations.

Information derived from remote sensors can, at the same time, contribute to an early recognition and warning of risks and enable policymakers to prevent the emergence of conflicts and to reduce their impact. Technology itself cannot guarantee security, but security might be enhanced by technological support. By using technology effectively, policymakers may be able to enhance the coping capacities of states and by that foster stability. Thus, an important question is whether technology is being used effectively. This will be looked into briefly by taking climate change as an example.[25]

The UNFCCC set up the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change, a multi-stakeholder program which aims at supporting countries to "improve their understanding of climate change impacts and vulnerability and to

[20] See <www.un.org/esa/sustdev/sdissues/information/info_decisions.htm> for document text.

[21] See <www.igospartners.org/index.htm> for more information.

[22] See <www0.un.org/events/unispace3/bginfo/activities.htm> for more information.

[23] See <www.gmes.info> for more information.

[24] See <earthobservations.org/> for more information.

[25] Climate change here is assumed to be "one component of the larger problem of direct man-made environmental change" (Paskal, 2007, p. 1)

increase their ability to make informed decisions on how to adapt successfully."[26] The "development and dissemination of methodologies and tools for impact and vulnerability assessments" has been decided to be an integral element of the Programme in decision 2/CP.11 (UNFCCC, 2007, p. 3). In a recent synthesis report, the UNFCCC collected the views of state parties and others on tools and methods available to and applicable by them in the framework of the Nairobi Work Programme and identified numerous problems (ibid, 2007). Among these are the lack of expertise and of technical and financial resources for scenario development, especially for socio-economic scenarios, required for impact assessments (ibid, 2007, p. 6). Another problem is related to downscaling tools, which are used to produce specific assessments for certain regions and to support local decision-making, as global assessments are far too low in their spatial resolution to be a good basis for that. While most of the reporting countries use methodologies for downscaling (e.g. the PRECIS model, which is sponsored *inter alia* by DFID and UNDP[27]) difficulties remain and are mainly related to accessibility and usability, i.e. a lack of computational resources, local observational data, (regional) expertise for the interpretation of results, etc. (ibid, 2007, p. 6). The choice of the right methodology is another problem. There is, for example, the approach of regional modeling to produce Regional Climate Models (such as PRECIS). It uses outputs of large-scale climate models as conditioning factors to drive regional and time-limited high-resolution simulations. Another option, statistical downscaling, feeds global climate scenario outputs into statistical models, which relate large-scale climate variables to local and regional variables. This second methodology is much more affordable but is not without its problems either. So this aspect needs further consideration (for background on and discussions of different methodologies see Wilby et al., 2004 and Mearns et al., 2003).

In sum, there are huge regional differences in data availability and the capacities to use them adequately. As UNFCCC put it, "despite the phenomenal increase in availability of climate and environmental data from satellite remote sensing" and "despite improvements in the overall understanding of, and ability to monitor and model, the global climate system", serious deficiencies remain (UNFCCC, 2006, p. 8). And the G8 Gleneagles Plan of Action 2005 noted that "Africa's data deficiencies are greatest and warrant immediate attention" (quoted from ibid). In their national communications to the UNFCCC, a number of African countries have recognized and expressed their need for capacity-building and training (ibid, p. 14).

The Group on Earth Observation (GEO), with a focus on developing countries, has identified capacity-building as a necessity and outlined a lot of activities in the current work plan and established a Capacity Building Committee to this end (GEO, 2008).[28] However, when it comes to participation, despite significant increases in membership (GEO encompassed 72 member states and 46 participating organizations, including the European Commission in 2007, date of the last progress report) a remarkable number of African countries are not members and thus not included in planning and decision-making processes and other activities. This is problematic in different respects. A lack of inclusion and participation can explain low acceptance and use, it is an obstacle to global coordination and data-sharing and it has to be assumed that this also implies little or no consideration of the priorities and interests of these non-members.

An early criticism of the inclusion of environment into mainstream politics, which can be dated back to the Stockholm conference of 1972 is that in doing so environment was "coopted by the mainstream interests of Northern industrial states and now is governed by an agenda that marginalizes the concerns of the developing world while exaggerating its contribution to the environmental crises" (Matthew, 2001, p. 6). Particularly the debate on climate change and security seems to be mainly driven by Northern countries (see e.g., the recent reports mentioned above) and despite all global coordination mechanisms it appears clearly that more dialogue is needed to include as many different perspectives and actors as possible.

Some organizations have started organizing regional workshops to this end, for instance to identify and address the actual and specific interests and needs of certain regions in the field of earth observation, most famously the Global Climate Observing System (GCOS), which set up a Regional Workshop Programme in 2000 following an invitation from the UNFCCC. Since then 10 regional workshops have taken place, all of which served to set up regional action plans.[29]

[26] See <unfccc.int/adaptation/sbsta_agenda_item_adaptation/items/3633.php> for more information.

[27] See <precis.metoffice.com/> for more information

[28] And of course numerous projects, which are conducted with the support of international institutions and donors attempt to specifically contribute to capacities in this area. UNOOSA collaborates with several African and European governments in the framework of the COPINE project, a satellite-based information exchange network amongst African experts and decision-makers to the end of strengthening the capabilities of African countries to respond to various societal needs. The United Nations Programme on Space Applications supports the establishment of regional centers for space science and technology education in developing countries (see footnote 26 for more information); The Assessment of Impacts and Adaptations to Climate Change (AIACC) was developed in cooperation with UNEP/WMO and the IPCC in 2002 and is particularly concerned with strengthening the capacities of doing assessments and increasing adaptive capacity and resilience in developing countries.

[29] <www.wmo.ch/pages/prog/gcos/index.php?name=rwp>

Capacity-building, cooperation and availability of (the required type of) data are core challenges. An enormous effort will be needed to deal with them adequately and this should not only target the government level. In developing countries, governments and academia are important partners, but, as Moench and Dixit (2007, p. 4) point out "risk is inherently local" and "most risk vectors lie below the radar screen of national governments." Proactive prevention of these risks is the best solution not just in ethical terms, which is practically often unlikely for numerous reasons (see discussion on early warning above and in the Summary). In one of its key sheets on climate change and poverty, DFID underlines that timely, comprehensible and functional information on climate variability can increase the "range of response options" or adaptive capacity of local populations in developing countries (DFID, 2004, p. 1). Disseminating usable and timely information on a local level and in developing countries is, however, not all that easy. Challenges are *inter alia* to integrate existing information into vulnerability assessments, strengthen instead of weakening traditional knowledge, and to take into account ephemerality of political initiatives in risk assessments (as most provide a long-term view only) (DFID, 2004). An example of what the implementation of such an approach could look like is the "Many Strong Voices" project steered by UNEP/GRID-Arendal, which uses, amongst others, satellite information to strengthen adaptive capacities of indigenous populations of the Arctic and on small island developing states while at the same time promoting their opportunities for participation.[30] This final point refers back to the initial quote from Agenda 21, which already in 1992 identified "bridging the data gap" and "improving the availability of information" as goals for the international community. Data collected with remote sensing methods can and should play an important role in this context. This *brief* has tried to sketch out that remote sensing data can have numerous beneficial applications related to environment, ranging from the strengthening of research capacities to preventing immediate and long-term threats to people's livelihoods and ecosystems both in developed and developing countries. Such benefits, however, do not develop on their own, and to achieve at least some of them, coordinated, cooperative, and responsible international efforts have to be made.

[30] See <polar.grida.no/activities.cfm?pageID=2> for more information.

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Annex


integration of
policies
and
Security
policy
interactions
political system
education

I Seminar Program

"Environmental security is a disarmament policy"[1]

Klaus Töpfer

Environment and Conflict

Evaluating and strengthening the means of interdisciplinary cooperation

GMOSS Seminar, 18–20 September 2007 in Bonn, Germany

Schedule of the Seminar

18 September
General approaches—Security Aspects

12 am–1 pm	Arrival of the participants
1–2 pm	Welcome snack
2–2:15 pm	Brief welcome by the organizers, introduction of participants
2:15–3:30 pm	Brainstorming on topics and goals, creation of a mind map and identification of important issues. Facilitators: Lars Wirkus and Peter Zeil
3:30–4 pm	Tea & coffee break
4–5 pm	"What does Security do? Locating GMOSS within competing discourses of security practice!". Expert input by Marc von Boemcken (BICC)
	—Discussion*—
5–6 pm	"Re-conceptualization of Security Strategies and the Status of the Political Process." Expert input by Dr. Meyer-Ohlendorf (Ecologic)
	—Discussion*—
6–6:30 pm	Summary of results of the day, brief outlook. Facilitators: Lars Wirkus and Peter Zeil
7:30 pm	Meeting on the market square to walk jointly to the restaurant.
8:00 pm	Dinner.

*The discussions aim at instigating as much input, opinions and comments from the participants as possible. Here, pre-prepared brief statements on the topics and the perspectives of all parties involved will be helpful in finding the interdisciplinary approach, which this seminar intends to outline. Lars Wirkus and Peter Zeil will be acting as facilitators throughout the course of the seminar.

In addition, expert input, especially on the case of Sudan, will be provided throughout the course of the seminar by Dr. Michael Ashkenazi (BICC).

[1] All quotes taken from: Woodrow Wilson International Center for Scholars, Environmental Change and Security Program (www.wilsoncenter.org/index.cfm?topic_id=1413&fuseaction=topics.item&news_id=95228).

19 September

Resource Conflicts, Political Aspects and Security Assessments Individual Approaches

9–0 am	"Environment, Resources and Conflicts." Expert input by Jolien Schure and Lars Wirkus (BICC)
	—Discussion*—
10–11:15 am	"Water-related Conflicts/Cooperation"
	a) "Lessons learned from PCCP." Expert input by Prof. Dr. Janos Bogardi (UNU-EHS)
	b) "Practical experiences from Western Asia." Expert input by Dr. Reza Ardakanian (UNW-DCP)
	—Discussion*—
11:15–11:45 am	Tea & coffee break
11:45–12:45 am	"Environmental Security Assessments—State of the Art and Experiences." Expert input by Jeanna Hyde Hecker (IES)
	—Discussion*—
12:45 am–2 pm	Lunch
2–3 pm	"Security Indicators Based on Macro-economic Analysis." Expert input by Dr. Francois Kayitakire (JRC).
	—Discussion*—
3–3:30 pm	Tea & coffee break
3:30–4:30 pm	"Early Warning Indicators Based on Policy Analysis." Expert input by Dr. Heinz Krummenacher (Swisspeace)
	—Discussion*—

GIS, RS and the Implementation of International Conventions

4:30–5:15 pm	"Monitoring of Multilateral Humanitarian Agreements." Expert input by Dr. Stefan Schneiderbauer (EURAC)
	—Discussion*—
5:15–6 pm	"Monitoring of Multilateral Environmental Agreements." Expert input by Peter Zeil (University of Salzburg)
	—Discussion*—
6–6:30 pm	Summary of some core results of the day, general discussion, brief outlook. Facilitators: Lars Wirkus and Peter Zeil
After 6:30 pm	Joint dinner

20 September
GIS & RS continued

9–10 am	"Effectiveness of Treaty Monitoring, Using Space-based Civil Remote Sensing Satellites." Expert input by Prof. Bhupendra Jasani (King's College)
	—Discussion*—
10–10:30 am	Tea & coffee break
10:30–11:30am	"Challenges in Treaty Monitoring." Expert input by Jun. Prof. Dr. Irmgard Niemeyer (University of Freiberg)
	—Discussion*—
11:30–12:15 am	Final discussion, collection of core results, outlook.' Facilitators: Lars Wirkus and Peter Zeil
	Conclusion and brief farewell by the organizers
12:15 am–1 pm	Lunch
1 pm	End of the workshop

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BICC at a glance

Research, Consultancy, Capacity-building...

BICC is an independent, non-profit organization dedicated to promoting peace and development, through the sustained and effective transformation of military-related structures, assets, functions and processes. Disarmament frees funds which can be used to combat poverty. Conversion allows for a targeted and best possible re-use of these financial resources. Both processes complement each other and contribute to improving human security.

In doing this, BICC recognizes that the narrow concept of national security, embodied above all in the armed forces, has been surpassed by that of global security and, moreover, that global security cannot be achieved without seriously reducing poverty, improving health care and extending good governance throughout the world, in short: without human security in the broader sense.

BICC's services can be divided into the following groups:

- Applied research (scientific contributions, background and evaluation studies, impact analysis, development of indicators collection and analyses of data) as well as work to accompany and implement projects.
- Consultancy (background analyses, recommendations for action, expert workshops).
- Capacity-building by designing concepts and modules for education and training.

It is BICC's mission to contribute to peace and development by designing measures to prevent violent conflict and to foster constructive transformation.

It is in the field of 'conflict' that the importance of BICC within the framework of the German research arena is most striking. BICC is an applied research institute whose work is characterized by a methodological and topical 'looping' of applied research, consultancy and capacity-building. BICC is in the process of reorienting and systematically enhancing its focus on research and consultancy, as can be seen in the fields of SALW control, demobilization and reintegration of former combatants, migration and diaspora, natural resources, security sector reform and the security of failed states.

Along with conducting research, running conferences and publishing their findings BICC's international staff are also involved in consultancy, providing policy recommendations, training, and practical project work. By making information and advice available to governments, NGOs, and other public or private sector organizations, and especially through exhibitions aimed at the general public, they are working towards raising awareness of the key issues that drive BICC forward.

BICC was established in 1994 with support from the State of North Rhine-Westphalia (NRW). The Center's Trustees include the two Federal States of North Rhine-Westphalia and Brandenburg as well as the NRW.BANK, and the Landesentwicklungsgesellschaft NRW (LEG).

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