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University of Hamburg
Research Group Climate Change and Security

Working Paper
CLISEC-22

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Keywords

adaptive capacity, climate change, climate-conflict-sensitivity, modeling, violent conflict, societal vulnerability

Abstract

In this paper we present a model of the causal relationship between climate change and violent conflict. The model can be used to understand the dynamics and interdependencies between the variables considered. In particular, the influence of the adaptive capacity of a society on its sensitivity of turning to violent conflict when being affected by continuous climate change is analyzed. To do so, the climate-conflict-sensitivity is differentiated with respect to climate change. We derive two fundamental scenarios: A positive adaptive capacity allows a society to protect itself against climate change but it also provides the ability for violent conflict. In contrast, with a negative adaptive capacity a society also loses its ability for violent conflict and cooperates for mere survival.

1. Introduction

Recently, considerable research has been conducted to improve the understanding of the relationship between climate change and violent conflict. Entire volumes have been dedicated to this issue (Gleditsch, 2012; Scheffran, Brzoska, Brauch, Link, & Schilling, 2012). Despite the progress that has been made in this field, it is still debated whether or not there is a causal relationship between climate change and violent conflict. While some researchers see a clear relationship between these variables (Burke, Miguel, Satyanath, Dykema, & Lobell, 2009; Hsiang, Meng, & Cane, 2011), others are more cautious with regard to a possible link between these quantities (Buhaug, 2010; Scheffran, Brzoska, Kominek, Link, & Schilling, 2012a), mainly because of the complexity of the subject matter.

Yet, the question can be posed: If violent conflict was to increase with progressing climate change, how would this relationship evolve? Models of the climate-conflict linkage, which are based on interdisciplinarily used variables like vulnerability, adaptive capacity, climate sensitivity, and exposure as defined by the Intergovernmental Panel on Climate Change

(IPCC, 2007a, p. 27), could help concretize what influence these different variables actually have on the potential societal effects of climate change. Such information on e.g. the likelihood of onset of violent conflicts could prove to be valuable for the adjustment of intervention or mitigation strategies.

Environmental changes such as climate change can affect societies directly in numerous ways (Scheffran, Brzoska, Kominek et al., 2012a): e.g. through severe weather events (Adger, Hughes, Folke, Carpenter, & Rockström, 2005; Kates, Colten, Laska, & Leatherman, 2006), sea-level rise (Klein et al., 2001), or irregularly changing precipitation patterns (Schilling, Freier, Hertig, & Scheffran, 2012). These changes can manifest themselves in altered availability of fresh water resources, food, and energy, or in adversely affected human health (WBGU, 2008). Furthermore, unequally distributed impacts can cause indirect effects via reinforced or changing inequality patterns (Kates et al., 2006; Marino & Ribot, 2012). Resulting social effects can include political events such as demonstrations, reinforced or changing hierarchies and politics (Kominek & Scheffran, 2012). And unequal changes in livelihood can cause social changes such as migration (Lindstrom, 1996) or cooperation (BenDor, Scheffran, & Hannon, 2009) on the one hand and conflict or violence on the other hand (Barnett & Adger, 2007).

While there are numerous studies about the climate conflict nexus that use empirical quantitative or qualitative approaches (see table in Scheffran, Brzoska, Kominek, Link, & Schilling, 2012b), models of climate-conflict linkages are rare (example in Devitt & Tol, 2012; see review in Scheffran, Link, & Schilling, 2012). Applying various concepts of climate change and conflict, most empirical studies in this field consider a selected set of climatic or weather-related variables (e.g. temperature, precipitation, extreme weather events) that are then correlated with particular aspects of violent conflict such as the number, intensity, or onset of armed conflicts (Scheffran, Brzoska, Kominek et al., 2012b). Nonetheless, while these studies can describe a specific issue of the climate change-conflict relationship, it is not easily possible to generalize their findings to make them usable for modeling purposes.

This paper looks to address the challenge of actually modeling the climate change-conflict relationship by developing a model of the climate-conflict-sensitivity (*CCS*), which is the ratio of a conflict function and a climate change function. In this approach, we assume that in general an increase in climate change affects society in such a way that the result is an increase in the occurrence of violent conflict. The model setup and the fundamental equations are based on this assumption and are presented in the subsequent section 2. The derivatives of the *CCS* can be used to answer questions such as whether the amplitude of a violent societal response increases or decreases, and whether the acceleration of the effect on violence increases or decreases with progressing climate change. This assessment is conducted in section 3. The results are discussed in section 4, section 5 concludes.

2. Setup of the model

To describe the direct and indirect effects of climate change on violent conflict, quantitative variables need to be defined. While the most important indicators of climate change (temperature, precipitation, number of extreme weather events) are relatively easy to measure directly, the societal influences on the causal chain between climate change and conflict are complex (Scheffran, Brzoska, Kominek et al., 2012a). Therefore, the latter are harder to quantify, which necessitates the use of characteristic indicators to depict the climate change impacts on society (Fig. 1).

In this model, the impact of climate change on a society depends on its vulnerability. Furthermore, the reaction of a society to turn to violence also depends on the conflict sensitivity of the society. If a society was not vulnerable at all, climate change would have no detrimental effect. And if a society was not sensitive to conflict at all, it would always react peacefully even if climate change was to strongly impact the society. Therefore, the causal relationship between climate change and violent conflict depends on two key intermediates: the societal vulnerability *v* and the society's conflict sensitivity *c*. Societal vulnerability is a composite variable that is assumed to consist of three components: the exposure *e* of the society to climate change, the climate sensitivity *s*, and the adaptive capacity *a* of the society (IPCC, 2007a, p. 27). Table 1 summarizes our definitions of the model variables and their defining equations, which are explained in the subsequent sections.

Tab. 1: Equations and variables used in the model

Exposure to climate change:

$$e_R\left(Cl,t\right) := k_{e_R}\left(t\right) Cl_R^2\left(t\right) \tag{1}$$

Adaptive capacity of a society:

$$a_R\left(Cl,t\right) := k_{a_R}\left(t\right)\cdot\left(e^t - \left(\frac{Cl_R\left(t\right)}{g_{a_R}\left(t\right)}\right)^2\right) \tag{2}$$

Vulnerability to climate change:

$$\begin{aligned} v_R\left(Cl,t\right) &:= f\left(e_R, s, a_R\right) = \frac{e_R\left(t\right)s\left(t\right)}{a_R\left(Cl,t\right)} \\ &= \frac{k_{e_R}\left(t\right) Cl_R^2\left(t\right) s\left(t\right)}{k_{a_R}\left(t\right)\cdot\left(e^t - \left(\frac{Cl_R\left(t\right)}{g_{a_R}\left(t\right)}\right)^2\right)} \end{aligned} \tag{3}$$

Conflict as a function of vulnerability and climate change:

$$\begin{aligned} Co_R\left(Cl,t\right) &:= v_R\left(Cl,t\right) c_R\left(t\right) Cl_R\left(t\right) \\ &= \frac{e_R\left(Cl,t\right)s\left(t\right)}{a_R\left(Cl,t\right)} c_R\left(t\right) Cl_R\left(t\right) \\ &= \frac{k_{e_R}\left(t\right)s\left(t\right)c_R\left(t\right)}{k_{a_R}\left(t\right)}\cdot\frac{Cl_R^3\left(t\right)}{e^t - \left(\frac{Cl_R\left(t\right)}{g_{a_R}\left(t\right)}\right)^2} \end{aligned} \tag{4}$$

a	adaptive capacity	*k*	constant for calibration, $k > 0$
Cl	climate change	*R*	index denoting the geographic region
Co	violent conflict	*s*	climate sensitivity
c	conflict sensitivity	*t*	time
e	exposure	*v*	vulnerability
g	level of climate change-related education, $g \geq 1$		

2.1. Climate change

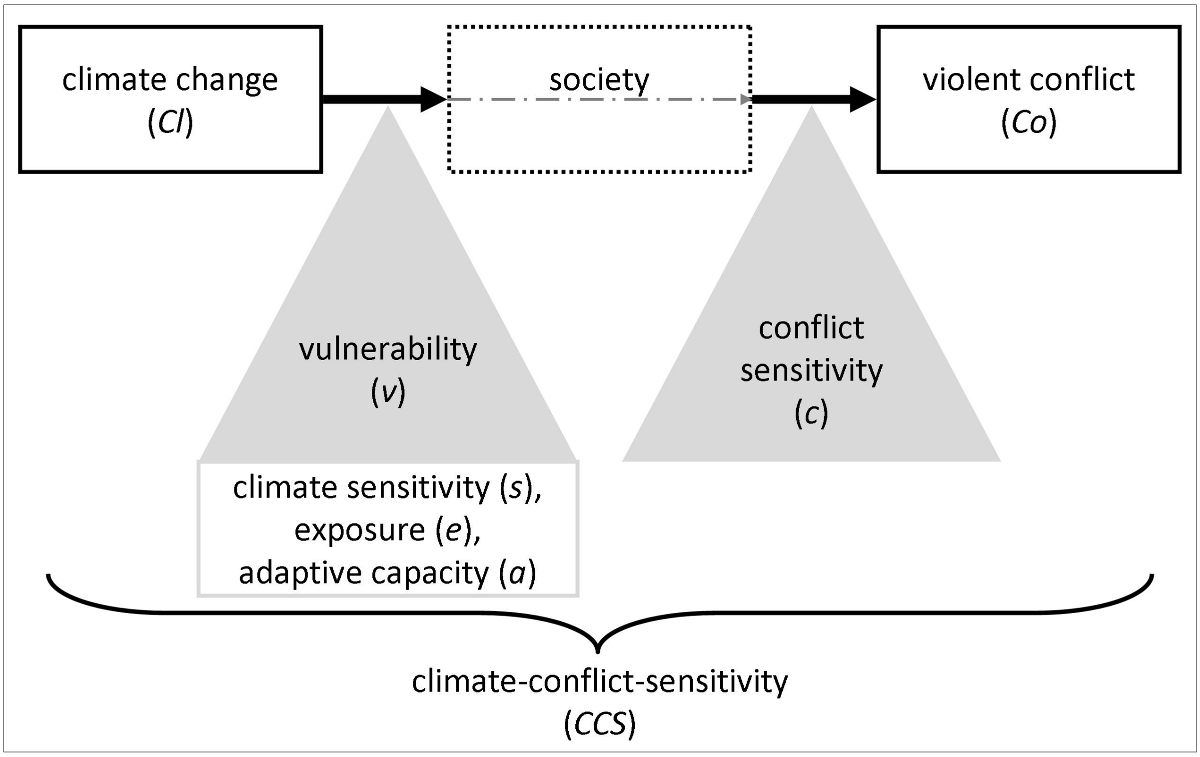
$$Cl_R\left(t\right) > 0 \tag{5}$$

The climate change function *Cl* is assumed to be positive over time (Eq. 5). In this model, it is an abstract variable. Thus, the climate change function does not refer to a specific indicator of climate change such as temperature or precipitation changes. For statistical purposes the climate change function would need to be defined more precisely in terms of measurable quantities and calibrated to fit with the other model functions.

2.2. *Climate sensitivity*

The climate sensitivity *s* is a global physical constant. It is defined as the equilibrium annual global mean increase in temperature for a doubling of atmospheric CO_2 equivalents compared to pre-industrial levels (IPCC, 2007b, p. 718). Therefore, it can be considered to be an indicator for the extent of the climate system's reaction to a particular amount of greenhouse gas forcing. However, it has to be noted that the current estimates of climate sensitivity vary considerably depending on the particular climate model used to determine this quantity.

Figure 1: Schematic overview of the model variables and their interdependencies.



2.3. *Exposure*

Because exposure is expected to increase with progressing climate change (IPCC, 2007a), the exposure function depends on the climate change function and a calibration function *k*, which is assumed to be positive (Eq. 1). While a linear function would be the simplest representation of this correlation, we have chosen to use a quadratic functional relationship to be able to cancel the climate change dimension in the vulnerability function.

2.4. *Adaptive capacity*

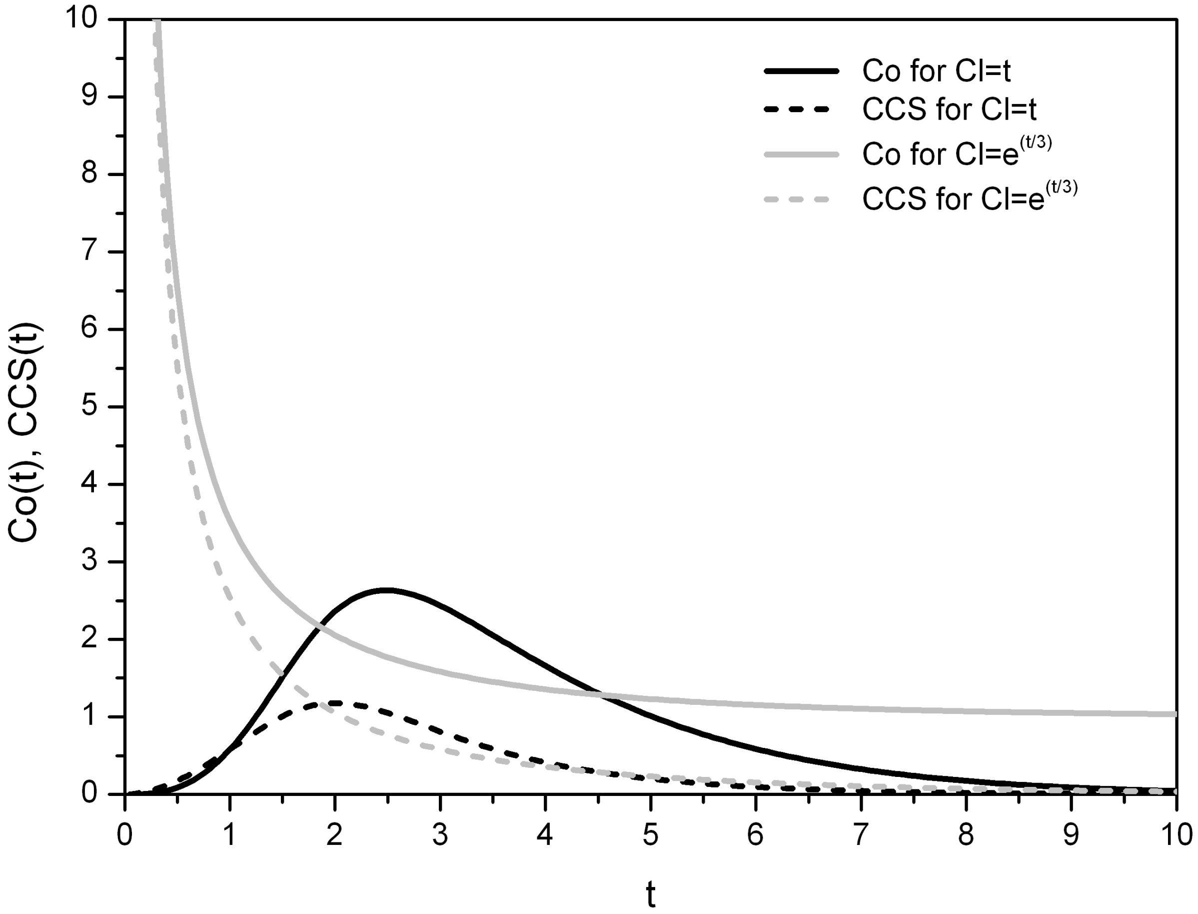
Some projections of previous technological developments into the future have led to the assumption that in the long run the exponentially increasing technological development can help to mitigate or cope with the impacts of climate change (Nagy, Farmer, Bui, & Trancik, 2012). But in the short run climate change may have regionally such large effects that present local technologies may be insufficient to adequately cope with them. Yet, a well informed society with knowledge on the potential regional climate change effects and best practice coping strategies may directly mitigate potential climate change effects. Thus, the adaptive capacity function consists of a technology-dependent part that increases exponentially over time. But this technology-based adaptive capacity is reduced by regional climate change effects, which are divided by a regional knowledge function (Eq. 2).

It is assumed in the adaptive capacity function that if the regional climate change effects do not increase exponentially over time, the exponentially growing technology-based part of the adaptive capacity will exceed them in the long run (for large t). But in the short run, a negative adaptive capacity function is possible if new technologies are not available quickly enough to offset regional increases in climate change effects.

2.5. Vulnerability

The definition of the vulnerability function is based on a three-fold understanding of vulnerability (IPCC, 2007a). It is defined to consist of the three multiplicative components – exposure, climate sensitivity, and adaptive capacity – and a calibration function that is assumed to be independent from climate change. In contrast to exposure and climate sensitivity, an increase in adaptive capacity, e.g. through technological innovation or a better informed society, reduces the vulnerability in the considered region and mitigates climate change effects. Thus, in the definition of the vulnerability function the product of the exposure function and the climate sensitivity is divided by the adaptive capacity function (Eq. 3).

Figure 2: Two examples of the conflict function and its corresponding climate-conflict-sensitivity.



2.6. Conflict sensitivity

The conflict sensitivity function is assumed to be positive. For zero conflict sensitivity, there would be no climate change-related conflict because the society would react to any changes in climate extremely peacefully. Then also the climate-conflict-sensitivity would be zero. Such a case would be trivial. In the subsequent analyses only non-trivial scenarios will be addressed using a positive conflict sensitivity.

2.7. Conflict

The violent conflict function is defined as climate change-related violent conflict only (Eq. 4) and does not refer to a measurable quantity such as the number of armed conflicts or battle deaths per year (e.g. Gleditsch, Wallensteen, Eriksson, Sollenberg, & Strand, 2002; PRIO, 2011; Raleigh, Linke, Hegre, & Karlsen, 2010). To allow statistical inferences, the underlying functions – vulnerability, conflict sensitivity, climate change, exposure, and adaptive capacity – and their constants would need to be calibrated. In this theoretical assessment (Fig. 2), we merely assume that the variables are related in the way that is described in the set definitions above (Tab. 1).

3. To which extent do conflicts increase with increasing climate change?

We assume that climate change-induced violent conflict exists. This generally implies that a worsening of climate change reinforces violent conflict. The question is whether the intensity of the influence of climate change on conflict changes with progressing climate change: Do the impacts increase or slow down with further progress of climate change? And does the speed of the change in impacts vary with further progress? In other words, does climate change lead to violent conflict more directly and with increasing speed or does its additional influence diminish with progressing climate change?

To address these questions, we define the climate-conflict-sensitivity (*CCS*) as an indicator of the relationship between the conflict function and the climate change function (Eq. 6). If the *CCS* was known, scientists could generate conflict scenarios on the basis of climate change scenarios.

$$CCS\left(Cl,t\right):=\frac{Co\left(Cl,t\right)}{Cl\left(t\right)} \quad \Leftrightarrow \quad Co\left(Cl,t\right)=CCS\left(Cl,t\right)\cdot Cl\left(t\right) \tag{6}$$

To understand the *CCS* more closely even without exact knowledge of future climate change, the following questions can be posed and answered in the subsequent sections:
How does the *CCS* change with increasing climate change?

$$\frac{\partial CCS\left(Cl,t\right)}{\partial Cl\left(t\right)}\geq 0 \quad \vee \quad \frac{\partial CCS\left(Cl,t\right)}{\partial Cl\left(t\right)}\leq 0 \ ? \tag{7}$$

Does the change of the *CCS* increase or decrease with increasing climate change?

$$\frac{\partial^2 CCS\left(Cl,t\right)}{\partial^2 Cl\left(t\right)}\geq 0 \quad \vee \quad \frac{\partial^2 CCS\left(Cl,t\right)}{\partial^2 Cl\left(t\right)}\leq 0 \ ? \tag{8}$$

The answers to these questions require the first and second partial derivatives of the *CCS* with respect to its climate change component. Therefore, the individual variables are inserted into the defining equation, the constants are combined in one term, and functions are substituted to simplify the equation for use in subsequent calculations:

$$
\begin{aligned}
CCS_R(Cl,t) &= \frac{Co_R(Cl,t)}{Cl_R(t)} = \frac{v_R(Cl,t)\cdot c_R(t)\cdot Cl_R(t)}{Cl_R(t)} \\
&= k_{v_R}(t)\cdot\frac{e_R(Cl,t)\cdot s(t)}{a_R(Cl,t)}\cdot c_R(t) \\
&= k_{v_R}(t)\cdot\frac{k_{e_R}(t)\cdot Cl_R^2(t)\cdot s(t)}{e^t-\left(\frac{Cl_R(t)}{g_{a_R}(t)}\right)^2}\cdot c_R(t) \\
&= k_{v_R}(t)\cdot k_{e_R}(t)\cdot s(t)\cdot c_R(t)\cdot\frac{Cl_R^2(t)}{e^t-\left(\frac{Cl_R(t)}{g_{a_R}(t)}\right)^2}
\end{aligned} \tag{9}
$$

Now the constants, which are independent of climate change, can be combined in the following way:

$$
m := \frac{k_{v_R}(t)\cdot k_{e_R}(t)}{k_{a_R}(t)}\cdot s(t)\cdot c_R(t) \tag{10}
$$

Substitution of the variables

$$
\begin{aligned}
x &:= Cl_R(t) \\
d &:= e^t \\
b &:= g_{a_R}(t)
\end{aligned} \tag{11}
$$

results in

$$
CCS_R(Cl,t) = m\cdot\frac{x^2}{d-\left(\frac{x}{b}\right)^2} \tag{12}
$$

with m > 0.

3.1. Differentiability of the CCS

Before turning to the questions concerning the change of the *CCS* and the speed of its change, the *CCS* function's differentiability needs to be checked to ensure that it is differentiable throughout the domain over which it is defined. In the definition of the *CCS* function all defining functions themselves are differentiable over their entire domains. The *CCS* function is defined for a non-zero adaptive capacity function (denominators must be non-zero). Therefore, also the *CCS* function is differentiable throughout the domain if the adaptive capacity is non-zero.

3.2. How does the CCS change with increasing climate change?

We now analyze whether the *CCS* and thus the likelihood of conflict increases or decreases with progressing climate change (Eq. 7). Partial differentiation of the *CCS* yields:

$$\begin{aligned}\frac{\partial CCS_R\left(Cl,t\right)}{\partial Cl_R\left(t\right)} &= m\cdot\frac{2x\left(d-\left(\frac{x}{b}\right)^2\right)-x^2\cdot\left(-\frac{2}{b^2}x\right)}{\left(d-\left(\frac{x}{b}\right)^2\right)^2}\\ &= m\cdot\frac{2dx-\frac{2}{b^2}x^3+\frac{2}{b^2}x^3}{\left(d-\left(\frac{x}{b}\right)^2\right)^2}\\ &= m\cdot\frac{2dx}{\left(d-\left(\frac{x}{b}\right)^2\right)^2}>0\quad\forall\, m>0\end{aligned}\tag{13}$$

Therefore, based on the model assumptions the regional *CCS* increases with increasing regional climate change effects. Thus, for a positive conflict function conflicts increase with increasing climate change effects and they do so at a growing rate. In the case of a positive conflict function a growing *CCS* means that if an increment of one unit on the climate change effects scale would initially cause an increase of one unit on the conflict scale, it would later have an amplified effect on the conflict scale. But does the *CCS* increase logarithmically or exponentially? Does the marginal increase of conflict eventually decrease with further increases in climate change effects or is this a self-reinforcing system with an accelerating growth of conflict for progressing climate change?

3.3. Does the change of the CCS increase or decrease with increasing climate change?

Further differentiation yields:

$$\begin{aligned}\frac{\partial^2 CCS_R\left(Cl,t\right)}{\partial^2 Cl_R\left(t\right)} &= m\cdot\frac{2d\left(d-\left(\frac{x}{b}\right)^2\right)^2-2dx\cdot\left(2\cdot\left(d-\left(\frac{x}{b}\right)^2\right)\cdot\left(\frac{-2}{b^2}x\right)\right)}{\left(d-\left(\frac{x}{b}\right)^2\right)^4}\\ &= m\cdot\frac{2d^2-\frac{2d}{b^2}x^2+\frac{8d}{b^2}x^2}{\left(d-\left(\frac{x}{b}\right)^2\right)^3}\\ &= 2dm\cdot\frac{d+\frac{3}{b^2}x^2}{\left(d-\left(\frac{x}{b}\right)^2\right)^3}\neq 0\quad\forall\left(m\neq 0\right)\end{aligned}\tag{14}$$

Therefore, two cases are possible:

$$\frac{\partial^2 CCS_R\left(Cl,t\right)}{\partial^2 Cl_R\left(t\right)}>0\quad\Leftrightarrow\quad d-\left(\frac{x}{b}\right)^2=a_R\left(Cl,t\right)>0\tag{15}$$

or

$$\frac{\partial^2 CCS_R(Cl,t)}{\partial^2 Cl_R(t)} < 0 \quad \Leftrightarrow \quad d - \left(\frac{x}{b}\right)^2 = a_R(Cl,t) < 0 \tag{16}$$

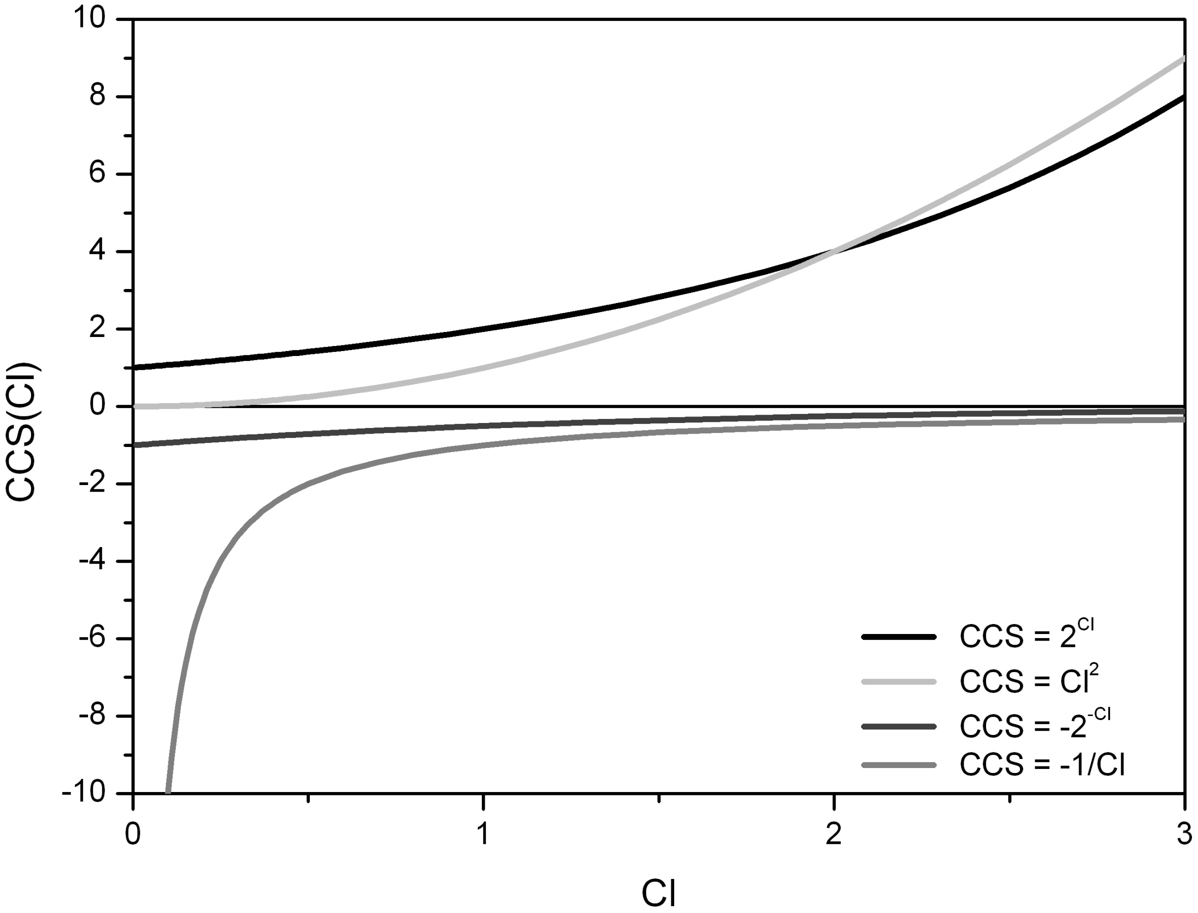
Thus, with a positive adaptive capacity the rate of change of the *CCS* increases, while with a negative adaptive capacity the rate of change of the *CCS* decreases with increasing climate change.

3.4. The two resulting scenarios

Tab. 2: Inequalities that describe two scenarios: positive adaptive capacity function (left) and negative adaptive capacity function (right).

$a_R(Cl,t) > 0$	$a_R(Cl,t) < 0$
$Co_R(Cl,t) > 0$	$Co_R(Cl,t) < 0$
$CCS_R(Cl,t) > 0$	$CCS_R(Cl,t) < 0$
$\frac{\partial CCS_R(Cl,t)}{\partial Cl_R(t)} > 0$	$\frac{\partial CCS_R(Cl,t)}{\partial Cl_R(t)} > 0$
$\frac{\partial^2 CCS_R(Cl,t)}{\partial^2 Cl_R(t)} > 0$	$\frac{\partial^2 CCS_R(Cl,t)}{\partial^2 Cl_R(t)} < 0$

Figure 3: Examples of a climate change dependent climate-conflict-sensitivity function that represent the two scenarios of a positive or a negative adaptive capacity.



The model can be used to describe two fundamental scenarios (Tab. 2): In one scenario the adaptive capacity is positive. This implies that the technological innovation, which increases exponentially over time, can be used to compensate for the occurring climate change effects. In this scenario the conflict function is positive and so is the climate-conflict-sensitivity. The first and second partial derivates with respect to climate change are positive as well, which entails that with increasing climate change conflicts increase more than linearly (Fig. 3).

In the second scenario the adaptive capacity is negative. This means that climate change impacts exceed technological innovation capabilities. Consequently, also the conflict function and the climate-conflict-sensitivity are negative. However, the first partial derivative of the climate-conflict-sensitivity with respect to climate change is positive while the second is negative. This implies a reduced growth of the *CCS* with increasing climate change (Fig. 3).

4. Discussion

Based on the assumption that an increase in climate change generally leads to an increase in violent conflict and further model assumptions based on definitions from the IPCC (2007a), the calculations show that violent conflict grows at an increasing rate with increasing climate change. If the adaptive capacity is positive, the conflict function is positive as well and the climate-conflict-sensitivity accelerates even more with increasing climate change. In contrast, for a negative adaptive capacity function the conflict function is negative and the climate-conflict-sensitivity levels out with increasing climate change.

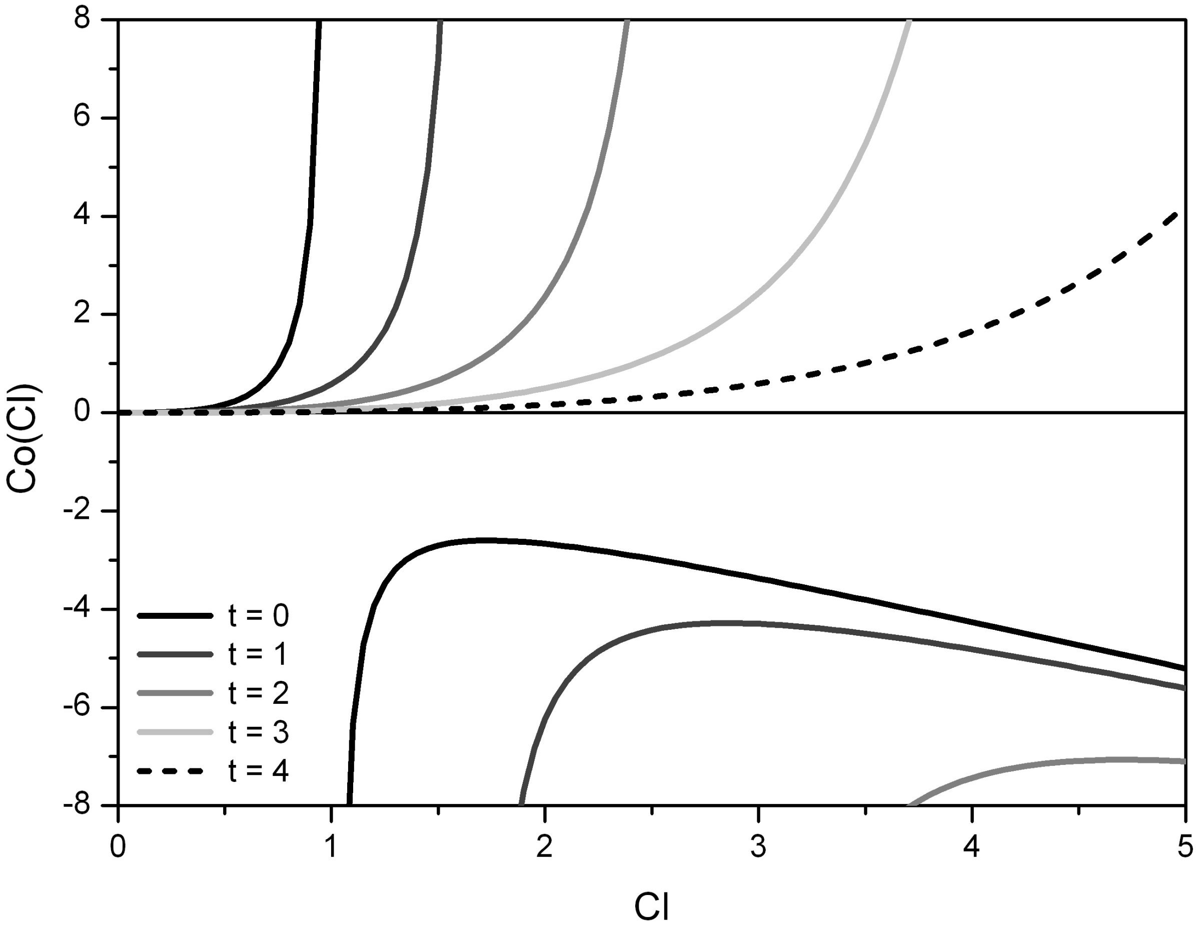
4.1. Negative adaptive capacity function

In the defining equation of the adaptive capacity function in this model (Eq. 2), the adaptive capacity can be negative if and only if the quadratic term exceeds the exponential term. This corresponds to the situation that the climate change effects exceed technological innovation. Because technological innovation is assumed to increase exponentially over time, climate change can only exceed it for a short period of time. The only other possibility is that climate change also grows at least exponentially over time. However, such a behavior would have strong negative effects (Lenton et al., 2008; Notz, 2009; UNFCCC, 2007; WBGU, 2008). Therefore, a negative adaptive capacity function implies strong negative side effects if it remains negative for an extended time period. But with a negative adaptive capacity function also the conflict function and the climate-conflict-sensitivity would be negative, which implies cooperation instead of conflict.

4.2. What would happen if the adaptive capacity vanishes?

In the model, the adaptive capacity function is assumed to be non-zero because for a zero adaptive capacity the conflict function and the climate-conflict-sensitivity would not be defined. But if the adaptive capacity function approached zero, the quadratic term, which mainly consists of the climate change function, would become almost equal to the exponential term of the technological innovation. In line with the argumentation of section 4.1, the shift towards the technological innovation function implies that the climate change function would increase more than exponentially over time. Additionally, the conflict function would also increase more than exponentially because of the way it is defined. If the adaptive capacity function approached zero while staying positive, the conflict function would increase to infinity (positive case in Fig. 4). In contrast, if it approached zero from the negative (cooperative) side, cooperation would rise to infinity (negative case in Fig. 4, approaching from the right). Therefore, a zero adaptive capacity is essentially a tipping point moving the system from conflict to cooperation or vice versa.

Figure 4: Conflict function over climate change for different time steps and all constants set to 1.



4.3. *What do the possible model dynamics actually mean for society?*

Consider a society in a region affected by climate change. If climate change increased more than exponentially over a short period of time so that the local society has hardly any adaptive capacity, there would be a large likelihood of conflict according to the model. If it increased more than exponentially for a longer period, leading to severe effects that the society is incapable of dealing with (negative adaptive capacity function), cooperation would rise again against the external enemy “climate” (negative conflict function). The ratio of the further progressing climate change to the increasing cooperation leads to something that should be called a “climate-cooperation-sensitivity” rather than a “climate-conflict-sensitivity”. However, the speed of change of the climate-cooperation-sensitivity slows down with further climate change (decreasing second derivative of the climate-conflict-sensitivity for a negative adaptive capacity). Once climate change progressed less quickly, technological innovation could be sufficient to produce solutions to again cope with further effects of climate change (positive adaptive capacity). But then additional climate change effects are more likely to cause conflicts again (positive conflict function, positive *CCS* function) and the climate-conflict-sensitivity would increase more quickly for further climate change effects (positive second derivative of the *CCS* function).

4.4. *Contradictions, limits, and applications*

In the model, a negative adaptive capacity function correlates with cooperation and a reduction in the speed of the negative but increasing *CCS* function, while a positive adaptive capacity function correlates with conflict and an increase in the rate of change of the increasing *CCS* function. This seems like a contradiction: adaptive capacity, which describes the ability to shade society from climate change impacts, correlates with conflict while its mathematically negative counterpart correlates with cooperation. This can be explained as follows: A negative adaptive capacity correlates with a climate change function that increases strongly over a short period of time. Therefore, an affected society is likely to suffer from strong impacts like flooding, storms, droughts, or severe health risks (IPCC, 2007a; UNFCCC, 2007; WBGU, 2008). Consequently, the situation they face would be shaped by severe effects on infrastructure, population, and health. Thus, their cooperative behavior would result from the joint necessity to merely survive.

The model neither allows inferences about the results of a negative climate change function, nor of a general underlying correlation that an increase in climate change would reduce conflicts. In the model, the climate change function is defined as positive over time and is generally positively correlated with the violent conflict function. But if there was no climate change, there can be no climate change related conflict. Additionally, various cases are considered in the discussion such as more slowly or quickly increasing climate change because for the adaptive capacity and the other functions not only the absolute values of the climate change function matter but also the function’s rates of change.

The functions in the model are mathematically defined for the purpose of analyzing the causal relationships among them. To apply the model to empirical data necessitates a scaling index that defines how the quantities considered need to be statistically combined. Important issues in this context are, e.g., whether the climate change function is measured in global surface temperature or precipitation, how exposure is computed, and how technological innovation and regional education are measured in order to deduce the adaptive capacity function as described in the model. Other details such as the influence of a democratic or autocratic governmental system are not included in the adaptive capacity function yet, even though scientists discuss indicators for the effects of the governmental system on the adaptive capacity of society (Brooks, Adger, & Kelly, 2005; Hinkel, 2011). In order to resolve regional differences, the calibration coefficients could be used either theoretically or in combination with empirical data.

All in all, this model can be used to understand the dynamics and causal relationships of the correlated variables it consists of, especially the adaptive capacity of a society and the societal sensitivity of turning to violent conflict when being affected by progressing climate change.

5. Conclusion

In this paper we present a model of the causal relationship between climate change and violent conflict. While in general an increase in the climate change function correlates with an increase in the conflict function and a reinforcing increase in the climate-conflict-sensitivity, the model allows for over-exponential increases in climate change, which corresponds to cooperative behavior and a slowing increase of a negative climate-conflict-sensitivity. The first scenario represents a positive adaptive capacity, which enables the affected society to shade itself against climate change but also provides the ability for violent conflict. The second scenario describes a negative adaptive capacity, in which the affected society has even lost the ability for violent conflict and cooperates to merely survive.

Based on empirical research (IPCC, 2007a; UNFCCC, 2007; WBGU, 2008), the second scenario appears to be only likely as a regionally confined short-term scenario, while the positive adaptive capacity scenario relates to the long-term projections if there is a generally positive overall causal relationship between climate change and violent conflict, as assumed.

The analyses show that on an abstract level different scenarios can be considered that can be applied to describe the interdependencies of vulnerability, adaptive capacity, exposure, and the climate-conflict-sensitivity of a society, which are characteristic indicators to depict the climate change impacts on society. Further sociological research is required to explain and understand the social mechanisms and behavior underneath these summarizing indicators, which are triggered by progressing climate change and may result in violent conflict.

Acknowledgments

The idea for this paper originated in the meetings and discussions of a manuscript published earlier in 2012. Therefore, the authors would like to thank the co-authors of that paper Jürgen Scheffran, Michael Brzoska, and Janpeter Schilling for valuable suggestions, as well as Jürgen Beyer. Research for this study was funded in part by the German Science Foundation (DFG) through the Cluster of Excellence “CliSAP” (EXC177).

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