Projecting Conflict and Cooperation under Climate Change Scenarios

White Paper for Discussion

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Summary

- Enhance the synthesis of conflict research and inter-comparison of conflict forecasting results
- Improve the use and interactions with the climate change community scenario framework
- Evaluate the complexity of the interactions of conflict and climate, especially the feedback of conflict and vulnerability to climate change
- Expand the modelling of governance and other elements of state fragility or failure as an important intersection of climate policy and conflict
- Investigate cooperative behaviour and other outcomes that foster social stability to produce scenarios where policies avoid conflict
- Improve the integration of the forecasting models and results with decision and policy-making needs

Will climate change lead to a more violent world?

Climate impacts are projected to be widespread, affecting multiple dimensions of human well-being[1]. One of the more contested impacts is whether climate change either directly or indirectly will lead to a more violent world[2,3]. With many of the effects from climate change, such as economic performance, food security and human displacement, also implicated in the propensity for armed conflict and unrest[4,5], there is reason for concern as these effects become more pronounced[6].

More recent reviews in a forthcoming special issue on climate change and conflict in Springer Current Climate Reports find little evidence that the physical impacts of climate change lead directly to group-level violence[7].

While there is some support for higher temperatures leading to increased interpersonal aggression, the relationships between group-level conflict and climate change appear more conditional, such as increased propensity for armed conflict in agricultural settings. Furthermore, governance and institutions, adaptive capacity as well as potential cooperative behaviors have also been emphasized as moderating factors in any potential relationship.

There is also an increased focus on theorizing and modeling the more complex relationships that are more appropriate for characterizing the climate and conflict links, such as the conflict-climate trap dynamics (e.g. conflict worsens the vulnerability to climate change which may then prolong conflict)[8,9]. Finally, more attention is being paid to the potential for conflict to emerge as a result of climate mitigation and adaptation policies (e.g. conflicts on land use)[10,11].

Forecasting methods can help us think more systematically about climate change and conflict

Forecasting comprises a range of methods that have unique advantages for thinking systematically about the evidence and pathways that may link climate change and conflict. These techniques can be used to:

1. Synthesize the available evidence on the climate and conflict relationship.
2. Explore different outcomes ranging from conflict to cooperation and model emergent dynamics.
3. Investigate trade-offs between climate change, climate mitigation and adaptation policies, and conflict.
4. Evaluate the potential and effectiveness of other interventions and initiatives (e.g. peacekeeping, the Sustainable Development Goal (SDGs), Sendai framework for Disaster Risk Reduction).

A brief history of forecasting conflict and political stability

Forecasting involves making predictions about the future using models based on actual data. Developing reliable forecasts of emergent conflicts and violence have long been of interest to the conflict and security community. This has resulted in a serious scholarship on the prediction of conflict; for a historical perspective and controversies on forecasting conflict, see[12–14]. Modeling efforts have looked at a range of violent outcomes, including the onset of interstate wars[15], civil war[16,17], and political instability[18,19].

A forecasting model consists of an underlying model of conflict projected over various future scenarios for the relevant variables. This may be a formal statistical model or a data mining effort (e.g. random forests). An out-of-sample evaluation approach is generally used to evaluate the performance of the models, in which a model is first estimated using training data, and then validated using reserved (i.e. out-of-sample) conflict observations. Out-of-sample evaluation is increasingly preferred to the traditional in-sample approach to modeling building (e.g. using all the data to build the model and then comparing the estimated conflict risk to actual conflict observation)[20,21].

Furthermore, out-of-sample validation approaches inherently place more importance on model predictive accuracy than on determination of individual variable significance, which yields more coherent, policy-relevant predictor constellations, since the latter are subject to overfitting, and are otherwise unable to reliably uncover structural causes of conflict from explanatory variables [15,18,20,22,23].

Structural statistical models for long-term country-level forecasts of armed conflict: The assignment of the conflict events to specific countries allow these models to employ information using models of correlates of conflict (e.g. GDP/capita, population, education, infant mortality rate, etc…). These models are used to investigate whether recent trends of lessening armed conflict will continue to the end-of-century along development scenarios[17], the interactions of conflict and challenges to mitigation and adaptation using the scenarios developed by the climate change research community[24], and conflict-trap dynamics[25].

Short-term early warning models: Machine-learning approaches are employed to predict the onset of conflict from information such as detailed news-based events data automatically extracted from online news sources. These models typically predict at a sub-annual level, providing short-term predictions/forecasts[23,26]. However, since the identification of the actors involved in events are imprecise and incomplete, these models are unable to make use of information on these actors, countries, or locations for which forecasts are made. A set of newer initiatives (e.g. VIEWS) seek to generate forecasts using the 'structural' approach but at a more detailed level of resolution than the country-year efforts[17,18,27], both temporally and spatially[21] and to develop forecasts for identified non-state actors.

Agent-Based Models (ABM) and Game-theoretic Models: ABM seek to uncover emergent, otherwise unforeseen, properties or structures in a complex system by modeling individual automata with *a priori* attributes and interaction rules to interact and modify one another over many iterations[28,29]. While there are practical difficulties parameterizing, validating, and integrating ABM with other modeling frameworks[30,31], agent-based forecasting methods may enhance the investigation of climate and conflict[9,32,33] as well as potentially complement its use in migration research [34–36]. Microeconomic concepts on game theory to employ information on the preferences and strategic constraints of identified actors to predict conflict and cooperation[37–40].

Expert elicitation or survey based predictions: There is a long history harnessing expert opinion through both structured scenario-based techniques and survey based approaches. These include both structured approaches, such as the Delphi methods and other foresight techniques[41] as well as approaches that aim to capture the "wisdom of crowds", especially for early warning systems[42]. Reviews of these expert-led forecasts, however, have concluded that they have limited success in predicting future conflicts and violence[43].

Forecasting conflict under future climate change and socioeconomic scenarios

Here, we highlight our work on developing credible projections of the implications of climate change for the future burdens of armed conflict and governance – an important variable at the intersection of conflict and climate change. We also emphasize incorporating armed conflict forecasting with the scenario framework developed and used by the climate change research communities to show the benefits for integrating research and policy analysis[44].

The scenario framework developed by the climate change research community starts with the Shared Socioeconomic Pathways (SSPs) – five pathways for future development over the century[45].

In increasing order of emissions, they are: SSP1 sustainability, SSP2 middle of the road, SSP3 regional rivalry, SSP4 inequality, and SSP5 fossil fuel development. Integrated Assessment Models (IAM) are used to quantify the land use and emissions changes associated with these scenarios[46]. The land and emissions are then the inputs for the climate modellers to run atmosphere-ocean general circulation models in the 6th Coupled Model Inter-comparison Project (CMIP6)[47]. Scenario Model Inter-comparison Project (ScenarioMIP) is designed to facilitate the integration of the climate model outputs and the SSPs for the impacts, adaptation and vulnerability (IAV) analysis.

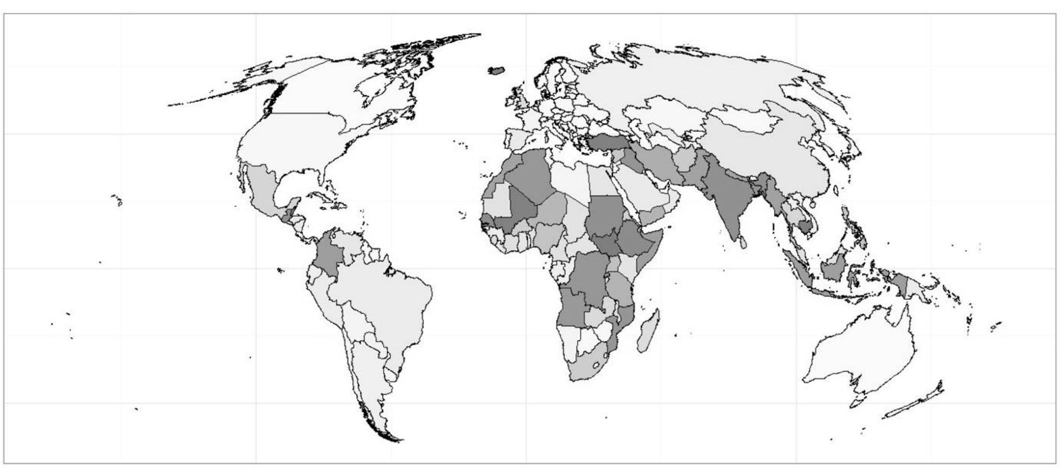
We outline four projects to highlight how our models can inform conflict and the SSPs: a) Projecting conflict along the SSPs; b) Using conflict modeling to inform the SSPs; c) Improving the coupling of conflict and governance modeling and IAMs; and d) Coupling short-term models to capture near-term, sub-national, disaggregated violence with the long-term forecasts.

Projecting conflict along the Shared Socioeconomic Pathways

Climate change and armed civil conflict are both inherently linked to socioeconomic development, although conditions that facilitate peace may not necessarily facilitate mitigation and adaptation to climate change. While economic growth lowers the risk of conflict, it is generally associated with increased greenhouse gas (GHG) emissions and costs of climate policies. Here, we investigated the links between growth, climate change, and conflict by forecasting the incidence of civil conflict along the SSPs[24] using the modeling approach described in Hegre et al.[17]. The projections are based on a statistical model of the relationship at the country-year level of analysis between internal armed conflict according to the Uppsala Conflict Data Program (UCDP)[48], log population size, log GDP per capita, educational attainment, log number of years since previous conflict, and log number of years since independence. This small number of variables represent the set of country-level variables the research community agrees are the most robust predictors of armed conflict, and for which we also have projections into the future. The projections follow the assumptions in the SSP that no new countries formed up to 2100, and make use of projections for population and educational attainment from IIASA and the OECD's GDP per capita.

In Figure 1, we show the difference in the conflict risk between SSP3 and SSP1. Two of the five SSPs imply a reversal of the recent decline in armed conflict, with end-of-century global conflict rate for SSP3 being twice as high as today's and four times higher than that projected for the optimistic SSP5. The main reason for the differences between these two sets of SSPs relates to socio-economic development. Internal armed conflict is to a large extent a poverty problem. SSPs that imply that a large number of developing countries to grow out of poverty also imply a substantial reduction in conflict. Importantly, however, while rapid, universal growth in GDP per capita is associated with substantial decline in the long-term risk of civil conflict, our model also shows that achieving broader socioeconomic development, as expressed by higher educational attainment rates in SSP1, offsets most of the additional risk from reducing economic growth between SSP5 and SSP1. The risk-reducing effect of education is especially pronounced among countries in the developing world. Thus, the sustainable future described in SSP1 is fully consistent with an ambition of global stability and peace while simultaneously having lower barriers to climate change mitigation and adaptation.

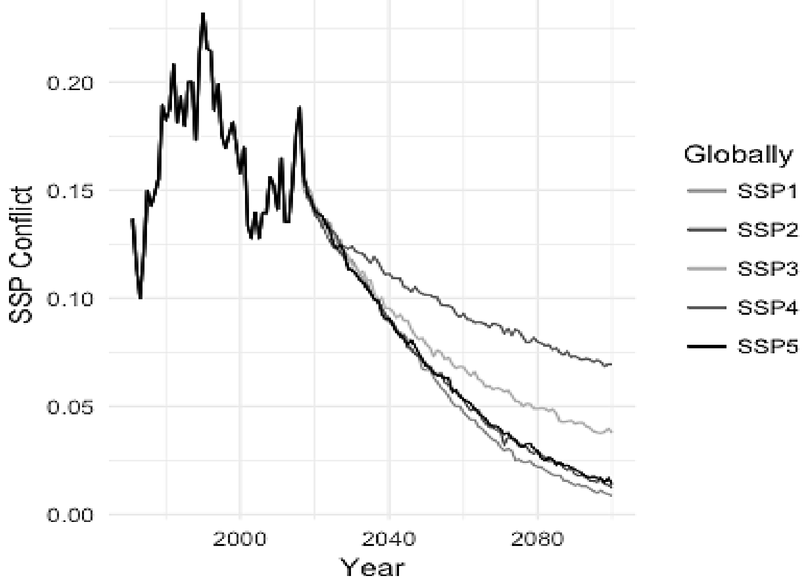
Figure 1: End-of-century differences in estimated conflict risk between SSP1 and SSP3. Darker shades indicate larger reductions in absolute conflict risk by shifting from a regional fragmentation scenario (SSP3) to a sustainable growth scenario (SSP1). There is insufficient historical data for South Sudan and North Korea.



Using conflict modeling to inform the Shared Socioeconomic Pathways

In Figure 2, we show an updated set of projections of armed conflict incidence based on a similar model as we used above, but using only the GDP per capita projections and employing conflict data up to and including 2016[49]. Projecting conflict along the SSPs shows overall optimistic futures for armed conflict. Up to 2016, the black line in Figure 2 represents the proportion of the countries in the world that had at least one internal armed conflict. This proportion increased steadily up to just after the end of the Cold war. In 1992, 23% of the countries in the world had an internal armed conflict. The global incidence of armed conflict then decreased to about 13% in 2001-2003 but has increased slightly over the last decade, with a discernible peak in 2014. In 2016, about 16% of the world's countries were in conflict. The simulations project a clear decline in the proportion of countries in armed conflict over the next 80 years. In the most pessimistic scenario (SSP4), the proportion of countries with conflict is reduced to about 7%. In the most optimistic (SSP1), armed conflict is predicted to all but disappear, with global proportions at about 1%.

Figure 2. Observed (1970-2016) and predicted (2017-2100) incidence of internal armed conflict globally for each of the five SSPs, operationalize by means of the OECD-ENV GDP projections and the IIASA population projections. In order of highest to lowest conflict risk, SSP4, SSP3, SSP5, SSP2 and SSP1.



What drives these optimistic projections? The admittedly rosy assumption of no new countries in the future accounts for some of the projected decline, but only a fraction. The main reason for the predicted decline can be found in the projections for population and GDP per capita. In fragmentation (SSP3), population exhibits the highest rate of growth, stipulating continued increase throughout the century and beyond. In the remainder of the scenarios, the global population peaks 2050 (SSP1 and 5) or 2070/80 (SSP2 and 4). However, population size is not the most powerful predictor of armed conflict, as demonstrated by the fact that our model predicts the highest incidence of armed conflict for Inequality (SSP4) which has a weaker population growth than SSP3.

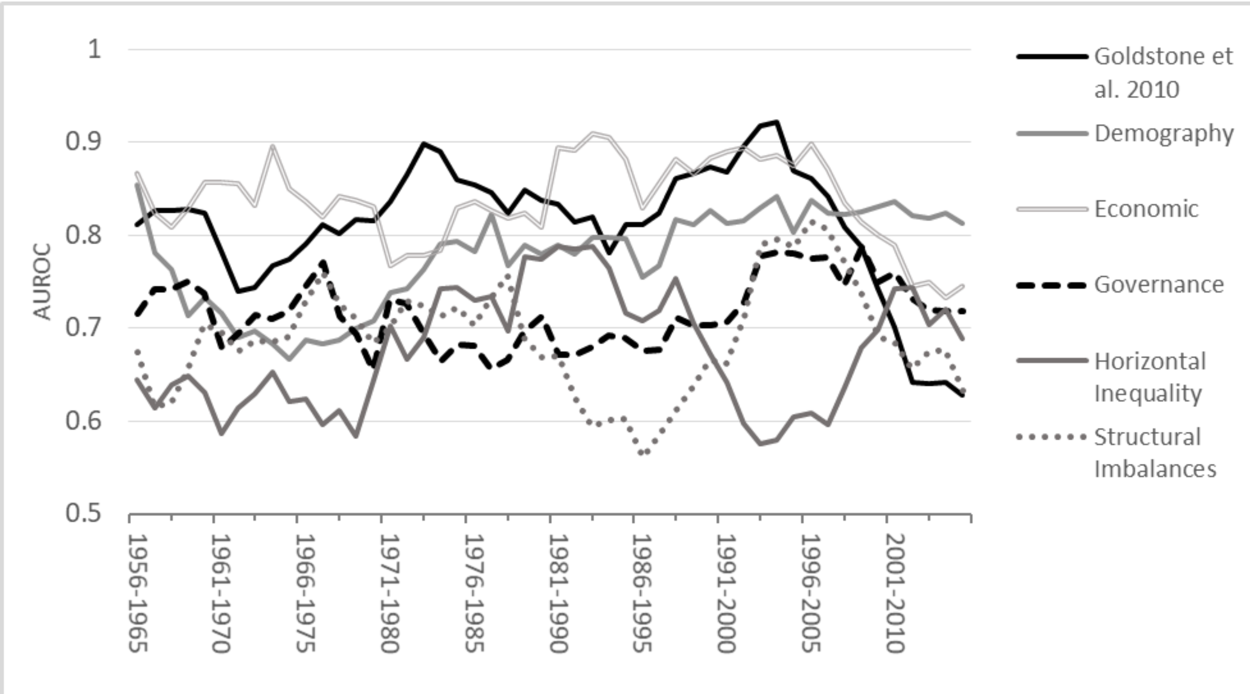
It is the optimistic growth projections that underlie the optimistic conflict predictions shown above. The conventional development (SSP5) scenario suggests an increase in average GDP per capita to close to 100 000 USD, much higher than any existing country today. The moderately optimistic projections (SSP1 and 2) indicate that the global average will reach levels at par with the current US level. The least optimistic (SSP3 and 4) suggest global income per capita to increase to levels more than twice that of the current average – average global income will be at the level of today's Spain. To achieve this growth, the world will have to grow at a rate as least as high as that observed over the past 45 years. That is not impossible, but hardly constitutes a pessimistic economic growth scenario.

Are these conflict projections credible? We think not, and for a specific reason. The OECD-ENV model is based on a convergence model, where growth within each country is determined by a set of assumptions regarding key drivers of long-term economic growth. As specified in the abstract to the paper, these include population, total factor productivity, physical capital, employment and human capital, and energy and natural resources (specifically oil and gas). Convergence in income rates come from convergence in these determinants, as specified by the SSPs. What is missing is the importance of political factors for both total factor productivity and the flow of capital among countries. A country such as Afghanistan, which have had intense violent conflict and dysfunctional politics continuously since the 1970s, is projected to have an income level of 95,000 USD under the Conventional Development scenario, which is hardly plausible. The projected income under the Inequality scenario (SSP4) is USD 6,300, four times higher than the current level and about the level of today's Egypt. Again, this is not implausible but constitutes in fact an optimistic projection. The projections should be corrected for the political constraints these economies operate within. For instance, an explicit modeling of the growth costs of armed conflicts would probably help yielding more realistic growth projections. We describe this in more detail in our description of how to couple IAMs and conflict forecasting.

Exploring alternative conceptual models for conflict: While the deep uncertainty inherent in foresight exercises requires thinking across distinct pathways of development (what was explored above), there are also debates about the drivers of domestic instability and conflict. For example, it is possible that even a middle of the road scenario will increase future conflict depending on the underlying model. Here, we unpack this potential uncertainty in the drivers of conflict comparing a well-known model developed by Goldstone et al. (2010)[18] with alternative models that we classify by the explanatory variables that are included as demography, economic, governance, horizontal inequality and structural imbalances. We construct conceptually distinct models from a subset of high performing variables that represent unique pathways to failure, with the intention that they might capture cases that a singular global model would miss. We explore these models along a "middle of the road" scenario that is very similar to SSP2 – the variables for these models were provided by extending the SSP2 along other the governance were developed using the International Futures (IFs) model described in more detail below. This effort can inform the development of other variables in the SSPs as determined by the performance of the model. We report the model performance as the Area under the Receiver Operating Characteristic (AUROC). This is a common summary statistic used to evaluate model performance; the closer AUROC comes to 1, the better the model's performance.

Figure 3 shows the classification behavior across time for Goldstone et al. (2010) and five conceptually distinct models. Because the original model from Goldstone et al. (2010) was calibrated with data through 2004, we first replicated the study and extended it to include the last 10 years of data (2005-2014). We find that the model's classification power sharply declines in the most recent decade, classifying 35% of cases correctly and failing to identify important events such as the Arab Spring Uprisings. The model's predictive power also varies significantly over time with two peaks, first during 1973-1982 and then in 1995-2004, which is also the period the authors use for out-of-sample validation in the original study. Temporal variation is also observed with the alternative models and several of the alternative models outperform the original model at different points across time – most notably in the most recent period. We hypothesize that these results are driven by the existence of multiple pathways to political instability (i.e. equifinality) and/or unmeasured periods of systemic upheaval that alter the drivers of political instability.

Figure 3. Moving decade AUROC scores for five distinct models and Goldstone et al. (2010)



Coupling conflict and governance forecasting with Integrated Assessment Models

Models of armed conflict and climate change both have at their core population, GDP, and other socio-economic variables as drivers of their outcomes. Understanding how these complex relationships may co-evolve over time is critical for identifying potential hotspots and conflicts, crafting development policies that both improve resilience to climate change and reduce the risks for armed conflict, and structuring climate policies that do not introduce new conflicts. There are important opportunities for linking conflict modeling with the Integrated Assessment Models (IAMs) that critical for evaluating climate policy and impacts[44]. Here, we provide two examples for how to incorporate conflict forecasting techniques with IAM. First, we review the International Futures (IFs) model[50] and the extensions for governance and conflict. Second, we highlight how outputs from the Global Change Assessment Model (GCAM)[51] can provide more information for the conflict forecasting models and opportunities for coupling these models.

Using International Futures (IFs) for modeling conflict and governance: International Futures (IFs) is a large-scale integrated global modeling system. It serves as a thinking tool for the analysis of near through long-term country-specific, regional, and global futures across multiple and interacting issue areas including agriculture, demographics, economics, energy, environmental, health, governance, infrastructure, and international political systems. IFs is data-driven and deeply rooted in theory. It represents major agent classes (households, governments, firms) and draws upon standard approaches to modeling specific issue areas whenever possible, extending those as necessary and integrating them across issue areas. Extensive linkages connect the separate sub-models, allowing users to analyze interactions across multiple issue areas.

In terms of the probability of internal conflict, IFs has forecasts built into the system as part of the Strengthening Governance Globally edition of the Patterns of Potential Human Progress series (PPHP)[52]. An extensive list of variables were examined, but ultimately the drivers were limited to variables that are forecast in the IFs system listed in Table 1. We modified the conceptual models to use these inputs only. These include regime type (expressed in terms of continuous polity score), trade openness, gross domestic product, and youth bulge. The Polity IV dataset covers all major, independent states in the global system over the period 1800-2015, monitoring regime changes in all major countries and provides annual assessments of regime authority characteristics, changes and data updates. The "Polity Score" captures this regime authority spectrum on a 21-pont scale ranging from -10 (hereditary monarchy) to +10 (consolidated democracy)[53]. These scores can be classified into three categories: autocracies, anocracies[1] and democracies.

Table 1: Summary of drivers for long-term forecasting model in IFs system

Model	Inputs (i.e. drivers)
Internal War Magnitude **Inspired by Goldstone et al. (2010)** **(SFINTLWARMAG)**	• Regime type (polity 21-point scale) • Trade Openness • Gross Domestic Product • Youth Bulge
Demographic (SFDEM)	• Infant Mortality • Population (logged) • Youth Bulge Pop (15+)
Economic/Development (SFECONDEV)	• GDP/cap (logged) • GDP/cap Growth • Life Expectancy
Governance (SFGOV)	Polity broken into 6 categories: • Full Autocracy (< -8) • Partial Autocracy (-6 to -4) & Partial Autocracy (-5 to 0) • Partial Democracy (1 to 3) & Partial Democracy (4 to 6) • Full Democracy (> 7)
Structural Imbalances (SFIMBAL)	• Polity v. GDP/cap • Life Expectancy v. GDP/cap • Youth Bulge Population (15+) v. Polity

In Figure 4, we forecast an index for internal war magnitude (SFINTLWARMAG) through the year 2050 using the built-in forecasts for internal war in the IFs system. On the global scale, we find lower risks associated with internal war. This is mainly because IFs forecasts overall improvement in development (which include demographic transitions that shift populations away from youth bulges) and shifts toward democratic institutions. One way to interpret these forecasts it to understand them as long-term risks associated with different pressures that can ultimately lead to state collapse.

In Figure 5, we forecast the models through the year 2050, in the IFs base case which is very similar to SSP2. On the global scale, we find that 3 of the 4 models forecast a long-term decrease in risk of state failure, much like the forecast for internal war magnitude developed for PPHP5[52]. Interestingly however, the governance model reveals more risk than the other models. This is because many states are forecast to transition from autocratic rule to anocratic regimes. The relationship between anocracy and state fragility is well established

[1] An anocracy is a government regime that is characterized by democratic and autocratic traits and features political instability and ineffectiveness.

in the literature[18,54]. Anocratic regime types are internally imbalanced because they mix inclusive governance structures with authoritarian systems. Breaking out regime type into intervals – in contrast to the built-in internal war forecasts in IFs which uses the continuous polity score – enables us to capture different effects depending on the specific regime-type (e.g. pure autocracy, partially autocratic anocracy or partially democratic anocracy).

Figure 4. IFs Global Forecast for State Failure Internal War Index, aggregated by simple average, historical data: consolidated events, maximum magnitude

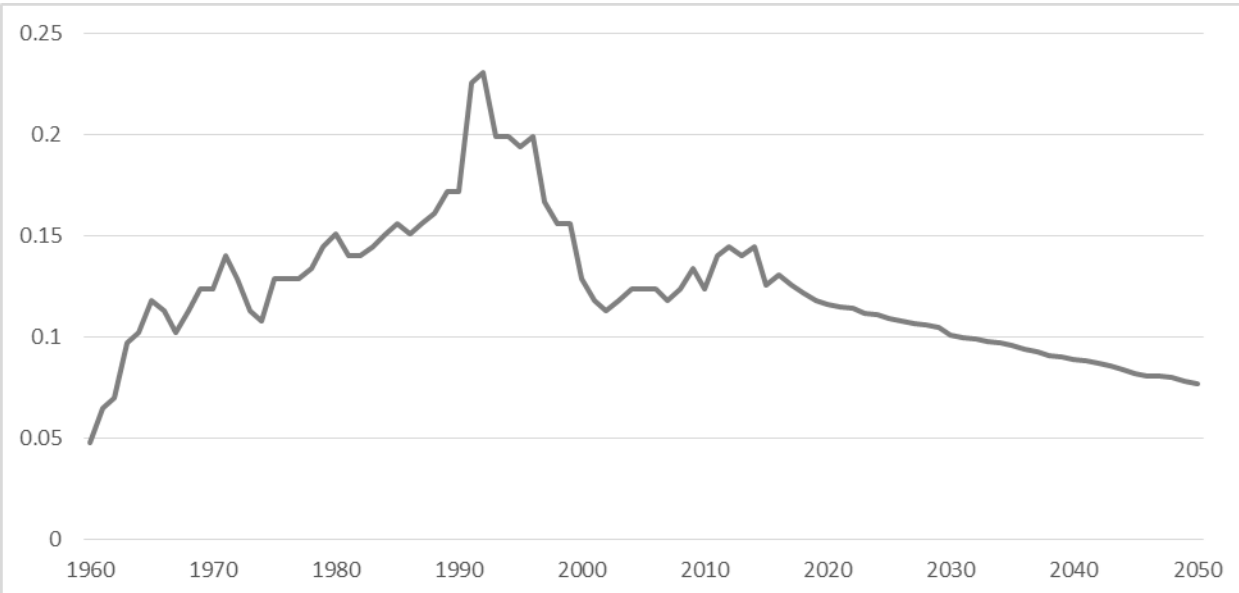


Figure 5. Long-term Global Risk of Conflict for Conceptually Distinct Models (aggregated by average)

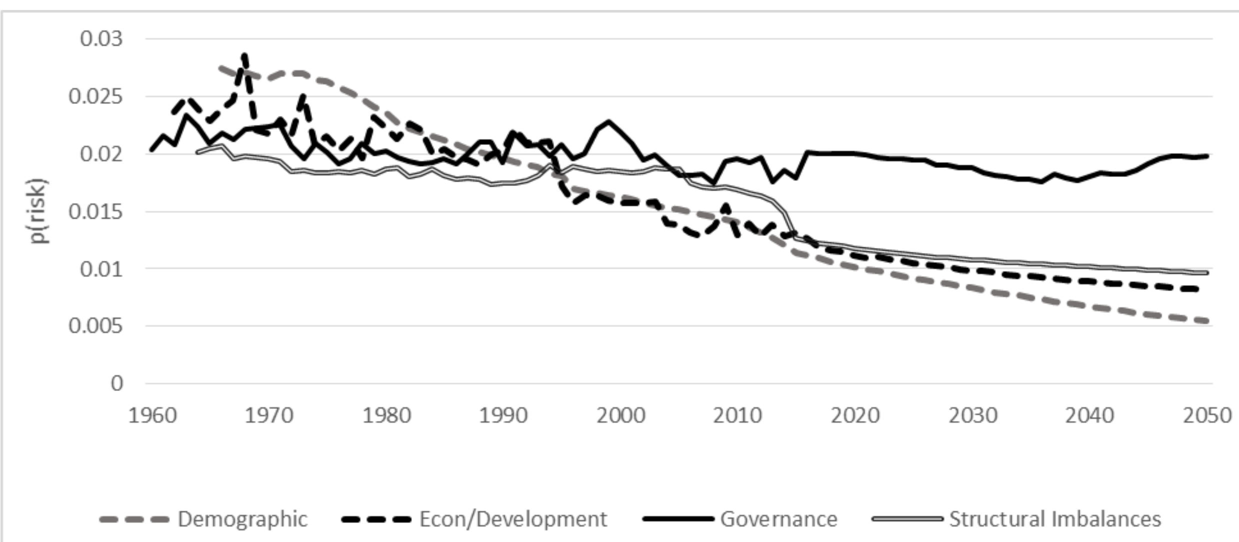
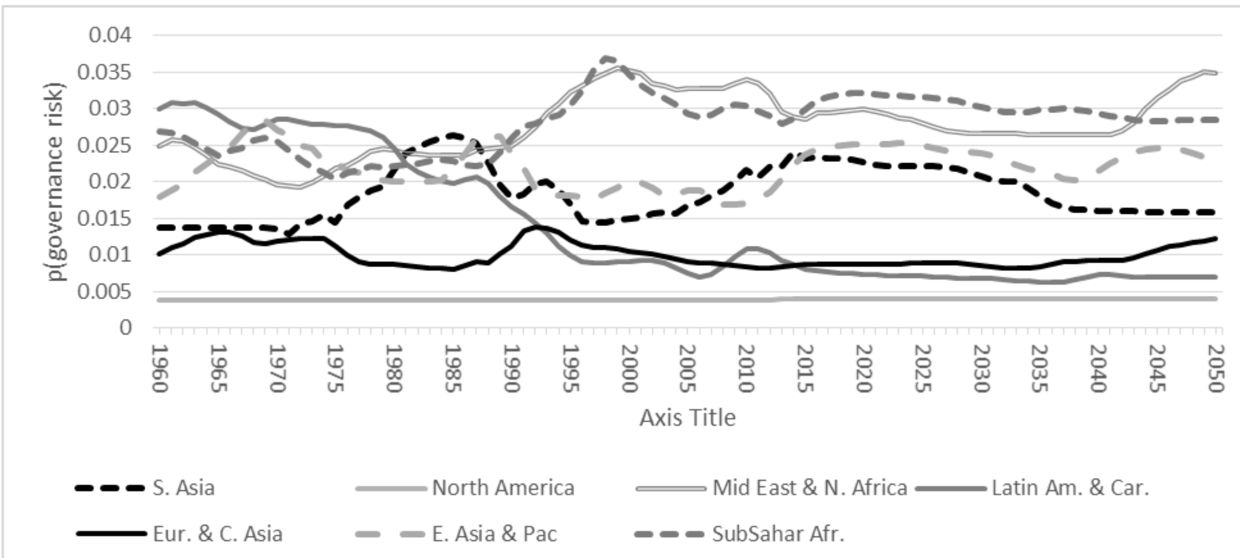


Figure 7 looks at the governance risks – the risk of moving along the polity scale – broken out by region along a baseline scenario. The greatest risk of increasing instability from governance exists in the Middle East/North Africa and Europe/Central Asia. In Sub-Saharan Africa, and East Asia/Pacific pressures associated with governance and instability are forecast to persist along a baseline scenario.to 2050. South Asia is the only area expected to decrease in risk, although it continues to be fairly vulnerable, particularly compared to Latin America and North America. Because they are expected to become more vulnerable over the long-term, the areas of most interest are the Middle-East/North Africa, and to a lesser extent, Europe/Central Asia. Figure 6 explore a few of the countries from these regions, which includes Azerbaijan, Belarus, Kazakhstan, Libya, Oman, and the UAE.

Figure 7. Risks Broken Out by Region for Governance Model (aggregated by average w/5-yr moving average)



Integrating conflict forecasts with GCAM: The Global Change Assessment Models (GCAM) is a global integrated assessment model and a direct descendent of the MiniCAM model[55]. It is a partial equilibrium model that links the economic, energy, land use, water, and climate systems. Over 32 geopolitical regions, global market-clearing prices of primary and secondary energy, agricultural and forest products are generated through 2100 at five-year intervals with exogenous improvements in technology and productivity and changes in demand from exogenous population and GDP. The climate system is represented by models of terrestrial and ocean carbon cycles, a suite of coupled gas-cycle, climate, and ice-melt models. The GCAM has been used to examine the effects of different mitigation strategies as well as climate change impacts and to develop the SSPs. We propose two opportunities to couple the GCAM with conflict forecasting approaches.

Modeling the "feedbacks" between the implied levels of armed conflict for each SSP, GDP growth and the potential challenges for climate policies. We simulate simultaneously the incidence of armed conflict and its effect on economic growth along the five GDP pathways defined by the Shared Socioeconomic Pathways (SSPs). We then model the implications for GHG emissions along the GDP pathways that account for the incidence of armed conflict using the GCAM Integrated Assessment Model described above. We expect that the more pessimistic SSPs have much higher incidences of armed conflict than predicted under the exogenously defined GDP pathways in the SSPs. Further, there are strong regional patterns; countries with conflicts experience much higher conflict burdens and reduced economic growth by the end of century. While the lower economic growth associated with armed conflict can reduce GHG emissions, the increase in political instability is more likely to hamper climate mitigation and adaptation efforts.

Conflict incidence, oil revenues, financial transfers and climate policy: Climate mitigation may alter future economic activity, especially oil production and revenue[56]. There is ample evidence in the conflict causing potential for financial flows, especially from oil[57,58]. We will develop quantitative projections of conflict propensity both globally and at a country level that may result from changes in economic performance (e.g. mitigation costs), oil production and revenues, potential financial transfers for carbon permits and other climate related activities under a range of climate mitigation policy options. GCAM will be used to produce a range of variables that are of interest for projecting armed conflict. The conflict forecasting model will make bounding projections of armed conflict under climate policies.

Short-term and early-warning systems for violence under climate change

The ViEWS project (http://www.pcr.uu.se/research/views/) seeks to combine the virtues of the structural[17,18] and the event-based[26] approaches discussed above. It will provide early warnings for armed conflict involving states and rebel groups, armed conflict between non-state actors, and violence against civilians. It is structural in the sense that it relates these conflicts explicitly to specific actors, sub-national geographical units, and countries and thereby can bring information on these entities into the models. It also leverages event data by employing the data resources of the UCDP, including the UCDP-GED event data[59]. VIEWS will also have a climate-related component making use of information on droughts, disasters, and temperature fluctuations at specific geographic locations, but only apply them for relatively short forecasting horizons (36 months).

Recommendations, challenges and opportunities

Enhance the synthesis and inter-comparison of conflict modeling results: The relationships between climate change and socioeconomic systems in general and conflict specifically are complex, as climate change is a long-term process with impacts experienced on timescales ranging from decades to centuries. Investigating the implications of our empirical relationships over long-term forecasts will also help assess the validity of these associations as well as asking questions about whether the relationships will hold over a century will remain stable. We can also leverage the increasing number of conflict forecasting efforts looking at the role of climate for inter-comparison efforts e.g.[24,27,50]. This could be part of an effort to improve and harmonize assumptions and documentation across the conflict forecasting community.

Conflict models, however, often include micro-level indicators at a spatial and temporal scale that may not be available in the SSPs. Additional work may be required to generate these variables, such as gridded info downscaled to a sub-national level[60,61].

Expand the modelling of governance and other elements of state fragility and failure as an important intersection of climate policy and conflict: Institutions are an important moderator in the conflict in general[62,63]. Taking a climate change lens, a large number of climate change mitigation and adaptation policies require that domestic political institutions have the capacity to implement them. For example, an international regime for carbon emission permit transfers, for instance, requires governments as reliable intermediaries. Also, policies designed to alter land use would be severely undermined by civil wars where large sections of the territory is forced out of such governments' control by parties that have absolutely no international recognition[10]. Similarly, increasing freshwater scarcity under climate change could increase conflict risk around transboundary river systems; this risk would best be offset by formal, institutionalized agreements[62]

Evaluate the complexity of the interactions of conflict and climate, especially the feedback of conflict into factors that affect vulnerability to climate change: In our first effort, the incidence of armed conflict did not feedback into the variables that operationalize the SSP scenarios. However, armed conflict poses substantial risk for vulnerability to future climate change by affecting economic growth, institutions and migration. Modeling these feedbacks between the implied levels of armed conflict for each SSP, GDP growth and the potential challenges for climate policies would enhance the policy relevance of these efforts. Relatedly, the operationalizations of SSPs that guide the actual forecasting efforts may also be too insensitive to armed conflict and other aspects of poor governance. The OECD-ENV forecasts for GDP growth, for instance, only build on projections regarding factors such as technological change and human-capital formation in a Solow-based convergence model, completely abstracting away from conflict and other institutional factors that affect economic productivity.

Explore the indirect links between climate change, conflict, and cooperation. The claim that the immediate, weather-related consequences of climate change such as fluctuations and shifts in temperatures and precipitation, or even instances of severe drought and natural disaster, are related to the risk of internal armed conflict is highly contested[64]. However, these events are likely to have important indirect effects that affect such behavior[65]. Climate-related events that crucially affect the livelihood of distinct population groups can have important indirect effects, as these groups are forced to find new avenues to sustain their activities. Especially when combined with poor institutions, such indirect effects may have a discernible impact on armed conflict. Additionally, less attention has been paid to the literature on cooperative behavior and environmental peacebuilding. These modeling efforts are also a good opportunity to provide more narratives and enhance the dialogue on the climate change and conflict by countering the more mechanistic/deterministic modeling and securitization of climate change[64,66]. Important future research goals include the need to analyze absence of conflict in the face of climate risks, a need to expand the range of issues accounted for in the analysis of climate and security, the need for robust theory to explain causal linkages, and the need to include theories of asymmetric power relations in explaining security dimensions[64].

Improve the integration of the forecasting models and results with decision and policy-making needs: Integrating the models with the scenario framework is one step in making the conflict forecasts relevant by being consistent with other efforts from the IAV community. This will also be especially important for the IPCC AR6 synthesis will the focus on mitigation and adaptation policies – e.g. the potential for conflict from land use scenarios and mitigation efforts[72]. The SSPs are designed to be used by many impact communities[67,68]. Here, conflict researchers have the opportunity to participate in this process by improving the measures of governance. Additionally, there are opportunities to interact and learn from many other communities that may face similar challenges for projection (e.g. the public health community) as well as benefit from other modeling teams who are developed forecasts of related variables, such as agriculture[69] and Sustainable Development Goals (SDGs)[70,71]. It is also important to consider the spatial and temporal scale of the output for decision-makers and these scales may vary depending on the intervention or planning that is being considered. Finally, there are also gains to be had by improving the visualization of the results, through improving representations of risk and uncertainty[73] as well as investigating how different visualizations influence perceptions[74].

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