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An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues

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ABSTRACT

Competition over limited water resources is one of the main concerns for the coming decades. Although water issues alone have not been the sole trigger for warfare in the past, tensions over freshwater management and use represent one of the main concerns in political relations between riparian states and may exacerbate existing tensions, increase regional instability and social unrest. Previous studies made great efforts to understand how international water management problems were addressed by actors in a more cooperative or confrontational way. In this study, we analyze what are the pre-conditions favoring the insurgence of water management issues in shared water bodies, rather than focusing on the way water issues are then managed among actors. We do so by proposing an innovative analysis of past episodes of conflict and cooperation over transboundary water resources (jointly defined as "hydro-political interactions"). On the one hand, we aim at highlighting the factors that are more relevant in determining water interactions across political boundaries. On the other hand, our objective is to map and monitor the evolution of the likelihood of experiencing hydro-political interactions over space and time, under changing socioeconomic and biophysical scenarios, through a spatially explicit data driven index. Historical cross-border water interactions were used as indicators of the magnitude of corresponding water joint-management issues. These were correlated with information about river basin freshwater availability, climate stress, human pressure on water resources, socioeconomic conditions (including institutional development and power imbalances), and topographic characteristics. This analysis allows for identification of the main factors that determine water interactions, such as water availability, population density, power imbalances, and climatic stressors. The proposed model was used to map at high spatial resolution the probability of experiencing hydro-political interactions worldwide. This baseline outline is then compared to four distinct climate and population density projections aimed to estimate trends for hydro-political interactions under future conditions (2050 and 2100), while considering two greenhouse gases emission scenarios (moderate and extreme climate change). The combination of climate and population growth dynamics is expected to impact negatively on the overall hydro-political risk by increasing the likelihood of water interactions in the transboundary river basins, with an average increase ranging between 74.9% (2050 – population and moderate climate change) to 95% (2100 - population and extreme climate change). Future demographic and climatic conditions are expected to exert particular pressure on already water stressed basins such as the Nile, the Ganges/Brahmaputra, the Indus, the Tigris/Euphrates, and the Colorado. The results of this work allow us to identify current and future areas where water issues are more likely to arise, and where cooperation over water should be actively pursued to avoid possible tensions especially under changing environmental conditions. From a policy perspective, the index presented in this study can be used to provide a sound quantitative basis to the assessment of the Sustainable Development Goal 6, Target 6.5 "Water resources management", and in particular to indicator 6.5.2 "Transboundary cooperation".

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1. Introduction

Future availability of freshwater for human consumption under a changing world represents one of the main concerns of the current political debate. Water crises have been placed among the major risk factors for the coming decades by the Global Risks Perception Surveys conducted by the World Economic Forum between 2015 and 2017 (WEF, 2017, 2016). Increasing demographic pressure, environmental degradation, and climate change impacts on water spatio-temporal distribution represent the largest determinants of current and future water related issues. Although it is intuitive that water stress is likely to increase the competition over water (Malthus, 1798), it is not completely clear how the combinations of factors influencing water demand and availability alone could lead to such different outcomes in different watersheds spread around the planet. Evidence shows that the consequences of comparable levels of physical water stress have been handled unevenly in different geographical areas and historical contexts (Wolf et al., 2003). Socioeconomic and cultural characteristics (Wolf, 2009), jointly with topographic factors (Beck et al., 2014; Gleditsch et al., 2006; Munia et al., 2016), were identified as the drivers more likely influencing hydro-political dynamics. Resource scarcity is likely to increase tensions, especially when associated with socio-cultural stressors (Sirin, 2011), but, on the other hand, the lack of a vital resource as water is also likely to boost cooperation between actors sharing the same freshwater sources (Bernauer et al., 2012b; Wolf, 2009, 2007; Wolf et al., 2003). The literature hardly identified common features between countries involved in water issues: similar levels of tension over water arose between countries independently of their climate zone, population size, territorial extension, level of democracy (Wolf, 2009). Moreover, the same international water issue frequently resulted in episodes of conflict and cooperation at the same time (Gerlak and Zawahri, 2009; Kalbhenn and Bernauer, 2012; Wolf, 2009; Wolf et al., 2003; Yoffe et al., 2004; Zeitoun et al., 2011; Zeitoun and Mirumachi, 2008). Although several cases of tensions, mostly non-violent, were also recorded, the literature shows that water related issues are more likely to be resolved with cooperation between the countries sharing the transboundary basins (De Stefano et al., 2010b; Wolf, 2009,2007; Wolf et al., 2003; Yoffe et al., 2004, 2003). Analyzing historical events, Böhmelt et al. (2014) concluded that physical availability and water demand components are only part of the aspects to be considered for the analysis of water related issues. The literature about political science, geopolitics, and diplomacy showed that also socioeconomic factors, jointly with institutional capacity, legal framework, and cultural background influence the diplomatic interactions between countries or actors sharing resources (Bernauer et al., 2012b; Wolf, 2009; Zeitoun et al., 2011) ([1]).

The goal of this study is to design an empirically based index aimed at analyzing and mapping the interactions between biophysical and socioeconomic factors linked to water issues at global scale. This was done analyzing water availability and demand, as well as socioeconomic, institutional, legal, and cultural context: factors that are likely to influence transboundary water issues. Final goal is to provide the policy maker with an instrument able to capture historical and current determinants of water related issues, but also the possibility to construct scenarios and simulate sets of policy options. The hereby presented index was calculated by applying a machine learning model on data layers at detailed spatial resolution for the assessment of water related issues and their determinants in the interactions between countries in transboundary basins.

1.1. Assessing the factors influencing water cross-border issues

1.1.1. From water conflict and cooperation events to water interactions

Political debate at the highest level had often expressed the concern for an increasing number of violent conflicts related to water resources use and appropriation, in particular in the cases of transboundary basins. Such concern brought to the inclusion in Agenda 2030 of a specific indicator on "Proportion of transboundary basin area with an operational arrangement for water cooperation"[2] (6.5.2), together with "Degree of integrated water resources management implementation" (6.5.1), for the assessment of Target 6.5 "Water resources management". Nevertheless, the analytic evidence of the correlation between violent conflicts and climatic factors is not completely clear (Buhaug, 2010; Kallis and Zografos, 2014; Zeitoun and Mirumachi, 2008), and thus the need emerges for methods oriented to pursue a scientifically sound and quantitative assessment of available information, as the one proposed herein.

The literature found a strong correlation between temperature (Burke et al., 2009), or drought events (Couttenier and Soubeyran, 2014), and civil war episodes in Africa. Buhaug (2010) firmly contested these findings and found the conflicts to be explained by structural and contextual conditions, such as: exclusion of ethnical groups from the political context, poor economic management, and geopolitical dynamics. Hsiang et al. (2011) proposed a meta-analysis based on 60 studies focusing on 45 historical conflicts on a global scale concluding that temperature and rainfall variability are significantly connected to violent events. Water related issues follow different dynamics respect to civil conflicts: historical water crises were often resolved with more or less satisfactory, formal or informal, agreements between the parties (De Stefano et al., 2010b). Water conflicts in history are, in fact, peripheral events and none of them reached a formal declaration of war (Böhmelt et al., 2014; Kalbhenn and Bernauer, 2012; Katz, 2011; Wolf, 1998, 2007, Yoffe et al., 2004, 2003). The fact that water war episodes were not recorded in the past does not imply that this could not happen in the future (Kallis and Zografos, 2014). Water related disputes were sometimes identified as igniting factors exacerbating international issues of different nature (Wolf, 2009). On the other hand, cooperation over transboundary basins often resulted in a benefit multiplier opportunity, associated with lower costs, increasing benefits and possibility for cooperation beyond water (Sadoff and Grey, 2002). In the analysis of historical hydro-political events, research points out that certain degrees of conflict and cooperation coexists in the same water related event (Gerlak and Zawahri, 2009; Kalbhenn and Bernauer, 2012; Wolf, 2009; Wolf et al., 2003; Yoffe et al., 2004; Zeitoun et al., 2011; Zeitoun and Mirumachi, 2008). For this reason, some authors (in particular Zeitoun and Mirumachi, 2008) claimed it would be more appropriate to analyze the transboundary water interactions, conflict and cooperation dynamics within the same water issue, regardless of their nature (Kallis and Zografos, 2014; Watson, 2015; Zeitoun and Mirumachi, 2008). In the proposed study, this approach was adopted focusing on the historical water interactions, rather than on the specific conflict or cooperation events linked with each of the water related transboundary issues, and use this as an indicator of the hydro-political risk, not intended as conflict risk, but rather risk of experiencing water related issues. As specified in Kalbhenn and Bernauer (2012), each water case underlying the interactions is defined as a water management issue that manifests in multiple interrelated interactions. For instance, the construction of a dam could represent a water case, while the protests of the downstream countries, of the affected stakeholders, the negotiations, and a possible international agreement would represent a series of events (conflict and cooperation) related to the specific case of the construction of our dam. Following Wolf et al. (2003 and 2009), conflictive and cooperative events were defined water interactions. In this paper, we will refer to the water interactions irrespectively of their specific nature and to more generic water issues or cases, defined as the water management aspects determining the interconnected water interactions, as for Wolf et al. (2003) and Yoffe

[1] An overview about this topic is provided, among others, by the Correlates of War Project (http://www.correlatesofwar.org/)

[2] http://www.sdg6monitoring.org/indicators/target-65/indicators652/