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

Arnaud Reynaud (TSE-INRA)

Joint with F. Farinosi, C. Giupponi, G. Ceccherini, C. Carmona-Moreno,
A. De Roo, D. Gonzalez-Sanchez, G. Bidoglio

Chaire Finance Durable et Investissement Responsable
Paris, Sept. 13th 2018

I. Water conflicts and water cooperation, especially in international river basins (IRBs)

II. Explaining and predicting hydro-political interactions in IRBs

Competition over water: Different problems & different scales

- Competition in transboundary basins → **Hydro-political risk.**

Regional,

Basin scale

  - Efficient allocation among riparian countries
  - Upstream/Downstream dynamics
  - International water treaties
  - International institutions (RBO)

- Competition between consuming sectors→ **Tensions between users**

National, Local

Sub-basin scale

  - Water allocation between productive sectors
  - Resource management (quality)
  - Water efficiency use

Two different approaches

- **Large scale (international river basins).** "A scientific literature has emerged that offers important insights into the factors that might influence international river basin cooperation and conflict" (Dinar and Dinar, 2003; Wolf et al., 1999; De Stefano et al., 2010; Zeitoun et al., 2010; Brochmann, 2012).

- **Local scale.** Latest research on conflictive and cooperative events at the local scale, concludes that changes in demand-side drivers (population growth, urbanization, and agricultural development) have a strong impact on the water conflict risk (e.g. Bernauer et al. 2012, Kallis and Zografos, 2014)

Toulouse School of Economics

Water as a source of conflicts

Newsweek

The world is at war over water. 24th April 2015.

BBC NEWS AFRIQUE

A new dam on the Nile could trigger a war over water unless Ethiopia can agree a deal with Egypt and Sudan, writes the BBC's Africa Correspondent Alastair Leithead. 24 February 2018

A Malthusian vision:

- fiercer competition over water resources due to a growing population, an increasing water demand and climate change might lead to conflict
- Cooley (1984), Homer-Dixon (1999), Hensel et al. (2006), Lasserre (2007)

Water as a source of cooperation

- Transboundary cooperation over water is much more likely than violent conflict.
  - A majority of interactions between states over transboundary waters have been cooperative (Wolf, 2003).
  - Aaron Wolf (2000): more than 3600 water related agreements along the history
  - Violent conflicts due to water have been very uncommon (UNEP, 2002).

- One possible explanation
  - Water is a divisible good which make compromises over water allocation possible
  - Soubeyran and Tomini (2006) "While some scholars claim that water-based conflicts can never occur, this analysis identifies a negotiation interval whose size depends on water availability and asymmetry in productive ability between countries"
  - Role of institutions

Toulouse School of Economics

How to assess / measure water conflicts and cooperation in IRBs?

- Case studies (political sciences)

Descriptive analysis of interactions between riparian countries sharing an IRB (ex: Nile, Syr Daria, Ganges-Brahmaputra Basin)

  - Precise understanding of drivers of cooperation or conflicts in a specific context
  - Difficult to upscale results

- Event data (political sciences)

  - Schrodt and Gerner (1994) “nominal or ordinal codes recording the interactions between international actors as reported in the open press”
  - Used to understand or measure interactions between countries.
  - Also employed to analyze non-state actor’s behavior

Toulouse School of Economics

How to assess / measure water conflicts and cooperation in IRBs?

o Event data (political sciences)

- Water-related events recorded on cooperation-conflict from news-media sources intensity scale
- Coded on a conflict/cooperation intensity scale
- Usually aggregated to country-pair-river basin
- Gobal coverage and time (panel)
- Some challenges: media reporting gaps and biases, coding rules, aggregation issues, cost +++

- "… but arguably the best measurement approach we have " Bernauer (2017)

- Main datasets available: TFDD, IRCC, ICOW (river claims)

Toulouse School of Economics

International Rivers Cooperation and Conflict (IRCC) water event dataset

o IRCC water event dataset

- Developed by ETH Zurich
- Most extensive and recent event dataset on international river basin cooperation and conflict worldwide
- Their dataset covers 264 international river basins from 1997 to 2007.
- Information on water related events from news through BBC Monitoring (http://www.monitor.bbc.co.uk/).
- Most international river basins in their dataset are shared by 2 countries, some by 3 or 4 and only very few by 5 or more countries.

IRCC water event dataset

Water related events between riparian countries are characterized on a scale ranging from -6 (most conflictive) to +6 (most cooperative). This is the International Rivers Cooperation and Conflict IRCC scale.

Value	Type
+6	alliance
+5	official support
+4	agreement/commitment
+3	agreement of low scale
+2	verbal support
+1	minor official exchanges, talks or policy expressions
0	neutral acts
-1	mild verbal expressions displaying discord in interaction
-2	strong verbal expressions displaying hostility in interaction
-3	hostile actions
-4	breaking diplomatic relations
-5	any violent acts (that do not yet constitute a war)
-6	Violent conflict, formal declaration of war

IRCC water event dataset

Selected water events and codes for Niger RB

country1	country2	year	event	ircc
Benin	Cote D'Ivoire	2004	durable and shared development of the Niger river basin but without specifying any concrete measures.	3
Cameroon	Nigeria	2002	Nigerian President Obasanjo has advised the nine member countries of the Niger Basin Authority not to allow for the proliferation of dams along the River Niger so that a development plan could be drawn up on the utilization of the basin in a ma	1
Cameroon	Nigeria	2004	workshop to discuss Nepad short-term action plan on cross-border water resources management in Johannesburg, organized by African Development Bank following assessment study of seven river basins: Niger and Senegal, Nile, Congo and Lake Chad, Z	1
Burkina Faso	Chad	2004	durable and shared development of the Niger river basin but without specifying any concrete measures.	3
Benin	Niger	2005	Benin asked the International Court of Justice (ICJ) to recognize its sovereignty over islands in the Niger river that are currently disputed with Niger.	-2
Benin	Niger	2005	Both west African countries have agreed to go to the court with their border contest for sovereignty over a stretch of the Niger and several islands.	-2
Mali	Algeria	2004	workshop to discuss Nepad short-term action plan on cross-border water resources management in Johannesburg, organized by African Development Bank following assessment study of seven river basins: Niger and Senegal, Nile, Congo and Lake Chad, Z	1
Benin	Niger	2005	Niger has presented its submission to the International Court of Justice on sovereignty of the Niger River islands dispute with Benin.	-2
Cameroon	Nigeria	2004	durable and shared development of the Niger river basin but without specifying any concrete measures.	3

Toulouse School of Economics

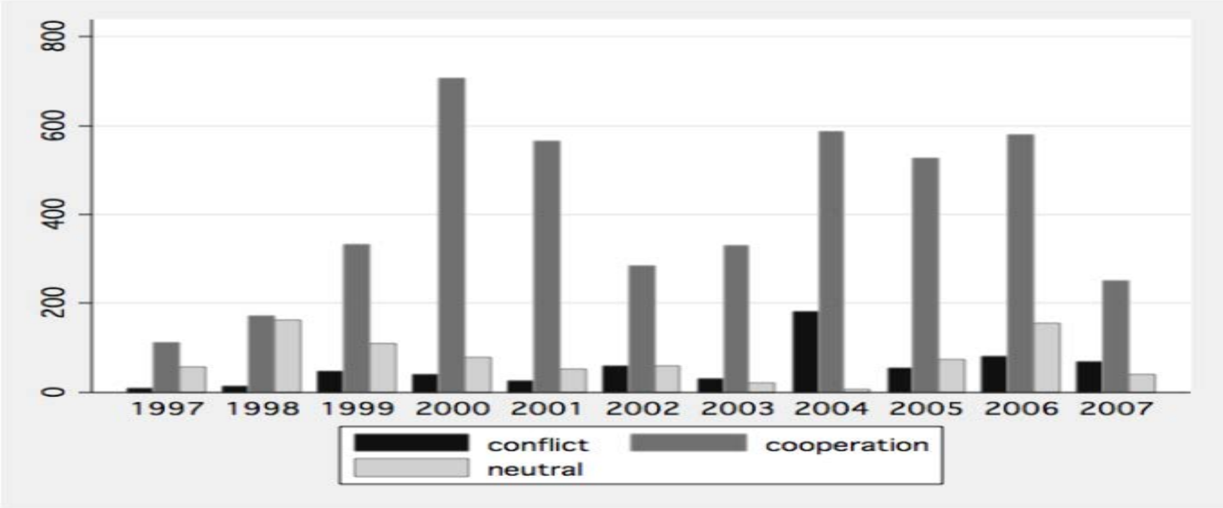
IRCC water event dataset

Selected water events and codes for Danube RB

country1	country2	year	event	ircc
Germany	Czech Republic	1997	Elbe is contaminated with highly poisonous chlorine substances. The poisonous waste reaches Elbe from the Czech chemical combine (Spolchemie). With Bonn's help a biological water purification plant is to be built there to reduce the emission.	4
Germany	Czech Republic	1999	Firemen managed to remove oil from the River Elbe which leaked from a store of the Ceskoslovenska plavba labska (CSPL) shipping company. It cannot be ruled out that the some oil escaped to Germany where it could cause great damage.	0
Germany	Czech Republic	2001	Together with Germany the EU invested about 250m korunas for the construction of the sewage pipeline and a central sewage station in Decin-Boletice.The Decin sewage plant will clean the Labe (Elbe) river waters annually of 320 tonnes of nitroge	4
Germany	Czech Republic	2002	Czech, German ministers tour flooded plant.Trittin and Ambrozek agreed on a joint plan of the protection of the Elbe against new floods	3
Germany	Czech Republic	2002	damaged barge drifting towards Germany	0
Germany	Czech Republic	2002	fears of chemical pollutants flowing down the Elbe from the Czech Republic.	0
Germany	Czech Republic	2002	Five ships which broke loose and damaged a high-pressure gas pipeline. There is a danger that the ships will cross the border with Germany, the regional emergency staff told their German colleagues.	1
Germany	Czech Republic	2002	German minister to view serious situation in flooded Czech chemical plant	3
Germany	Poland	2002	conference on sustainable development and flood defence	3
Germany	Czech Republic	2002	Most Czech sewage plants destroyed by floods, life in rivers endangered	2
Poland	Czech Republic	2002	conference on sustainable development and flood defence	3
Austria	Czech Republic	2003	Greenpeace protest against Spolana management	0
Germany	Czech Republic	2003	German Environment Minister launches Labe water purity measuring station	3
Germany	Czech Republic	2004	Dispute between the Chamber of Deputies and the Environment Ministry over the construction of weirs on the Labe.	-1
Germany	Czech Republic	2004	dispute over building of two dams on lower Labe spills out to Germany	-1
Poland	Austria	2005	conference on the Elbe	3
Germany	Czech Republic	2006	tonnes of fish killed. Saxony's Environment and Agriculture Minister complained	-2
Germany	Czech Republic	2006	TCyanide kills at least nine tonnes of fish	0

IRCC water event dataset: What do we know?

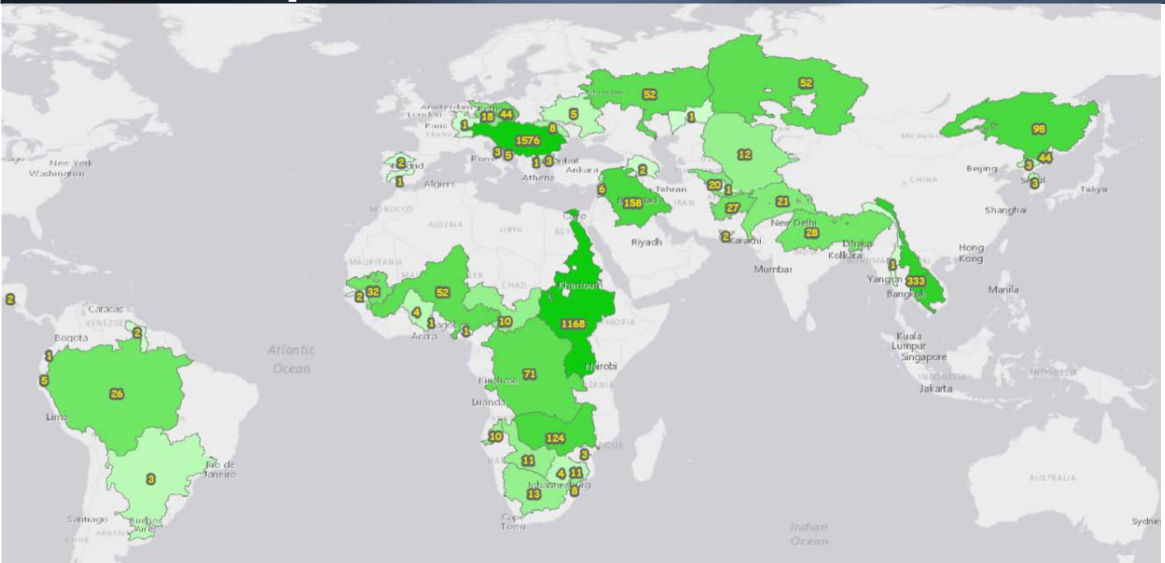
- No water event (neither cooperative or conflict) in many IRBs of the world
- When observed, far more cooperative events than conflictive even, no "militarized interstate dispute" over water per se (Bernauer, 2016)



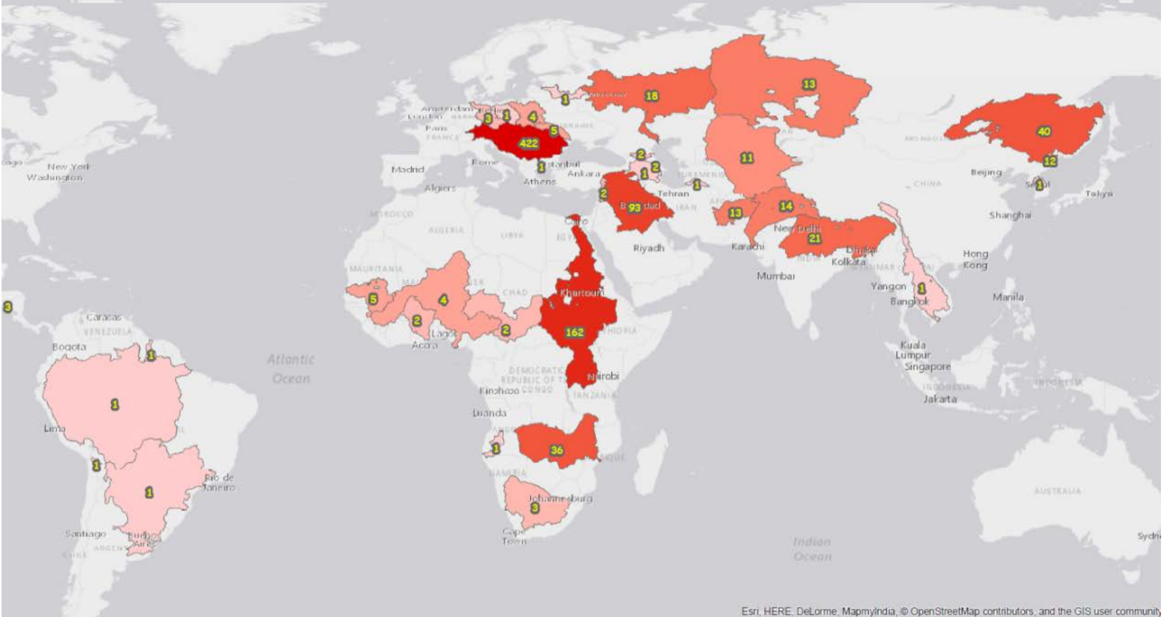
- Most observable events deals with water quantity or infrastructure; events concerning water quality and groundwater have recently increased.

Toulouse School of Economics

IRCC water event dataset: Cooperative & conflictive events per IRB



Count of cooperative events in IRBs in the IRCC dataset



Count of conflictive events in IRBs in the IRCC dataset

Understanding and predicting cooperative & conflictive events in IRBs

- Use of statistical/econometric work to identify structural factors that could explain differences in water cooperation/conflict across IRBs and across country pairs

- In general the predictive power of estimated models is relatively low.

Understanding and predicting cooperative & conflictive events in IRBs

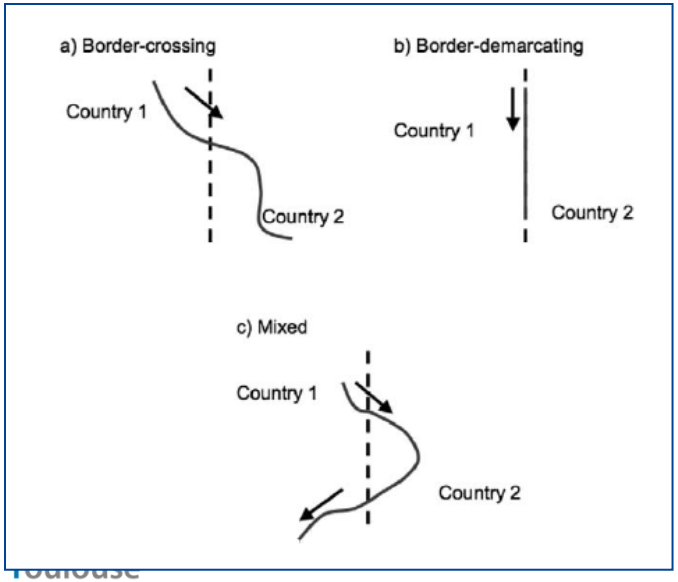
o Biophysical drivers

- climate conditions
- water availability →
- water dependency

> - *Neo-Malthusian's vision*
> - *Resource scarcity is associated with antisocial behavior, Prediger et al. 2014.*

- territorial shares of countries

- spatial configuration →



Toulouse School of Economics

Understanding and predicting cooperative & conflictive events in IRBs

o Political drivers

- Political regime →
  - *Democracies tend to cooperate more (Bayer, 2010; Leeds, 1999; Mansfield, Milner & Rosendorff, 2002; McGillivray & Smith, 2004)*
  - *Especially jointly democratic countries behave more cooperatively towards each other (cf. Leeds, 1999)*
  - *True for sharing natural resources (cf. Bernauer & Kuhn, 2010).*
  - *Authoritarian regimes have less domestic water conflict than democracies, they have more violent conflict (Bernauer et al. 2012).*
- Political relationships
- Membership in IGOs and INGOs →
  - *Joint membership in IGOs and INGOs can decrease the transaction costs of negotiating a treaty and assist in its enforcement. Zawahri, 2011.*

Toulouse School of Economics

Understanding and predicting cooperative & conflictive events in IRBs

o Economic / social drivers

- GDP →
  - *Economic strength indicates ability to sustainably manage shared resources*
- Trade dependency →
  - *Trade interdependencies may facilitate implicit side-payments and issue linkages and thereby increase intergovernmental cooperation (Sigman, 2004)*
- Water pressure
- Market mechanisms

Toulouse School of Economics

Understanding and predicting cooperative & conflictive events in IRBs

o Institutional drivers

- RB management capacities →
- RB international organization
- Governance
- Water monitoring systems

- *Although the existence of a river treaty among the riparians does not prevent future water disagreements, states are more likely to enter into negotiations to resolve these disagreements if there is a treaty in place (Brochmann & Hensel, 2009).*

Toulouse School of Economics

What we have done

- **Data**. Use of the IRCC water event dataset + additional global datasets (GIS)
- **Modeling**. Identify relevant drivers of water interactions across political boundaries.
- **Simulation & Mapping**. We map the evolution of the likelihood of experiencing hydro-political interactions over space and time, under changing socioeconomic and biophysical scenarios

Global Environmental Change 52 (2018) xxx–xxx

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

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

F. Farinosi[a,*], C. Giupponi[c], A. Reynaud[b], G. Ceccherini[a], C. Carmona-Moreno[a], A. De Roo[a], D. Gonzalez-Sanchez[a], G. Bidoglio[a]

[a] European Commission, DG Joint Research Centre, Ispra, Italy
[b] Toulouse School of Economics - National Institute for Research in Agriculture (INRA) – University of Toulouse Capitole, Toulouse, France
[c] Department of Economics, Venice Centre for Climate Studies (VICCS), Ca' Foscari University of Venice, Venice, Italy

- **Results**. 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).

Toulouse School of Economics

II. Explaining and predicting hydro-political interactions in IRBs

Water « issues » in transboundary river basin

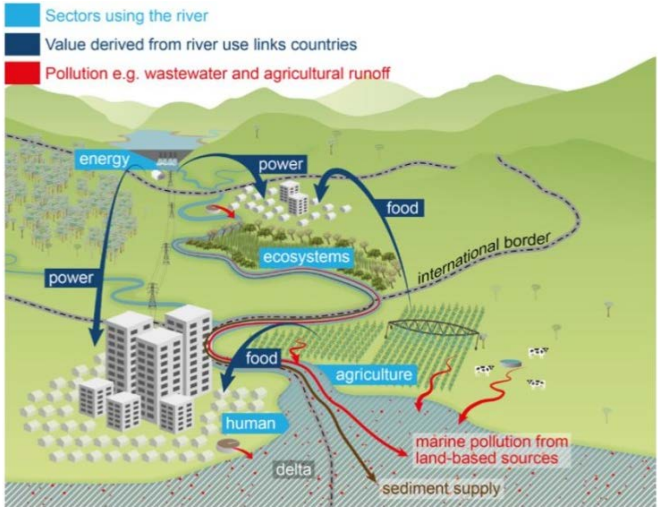
Hydro-political dynamics

Shared water

Water Issue(s):
- Allocation
- Management
- Quality
- …

Conflict

Cooperation



Toulouse School of Economics

Bringing together different aspects to understand the magnitude of **hydro-political interactions**

Biophysical & Climatic Factors

-Basin topography,
-Water availability,
-Precipitation,
-Temperature, etc.

Socio-economic Factors

-Gross Domestic Product,
-Governance indicators,
-Military and political strength, etc.

Management Factors

-Past treaties,
-River basin treaties, etc.

Explorative Analysis

Intensity of the Hydro-political interactions

Indicator measuring the probability of having water related interactions given the biophysical and socio-economic conditions

Toulouse School of Economics

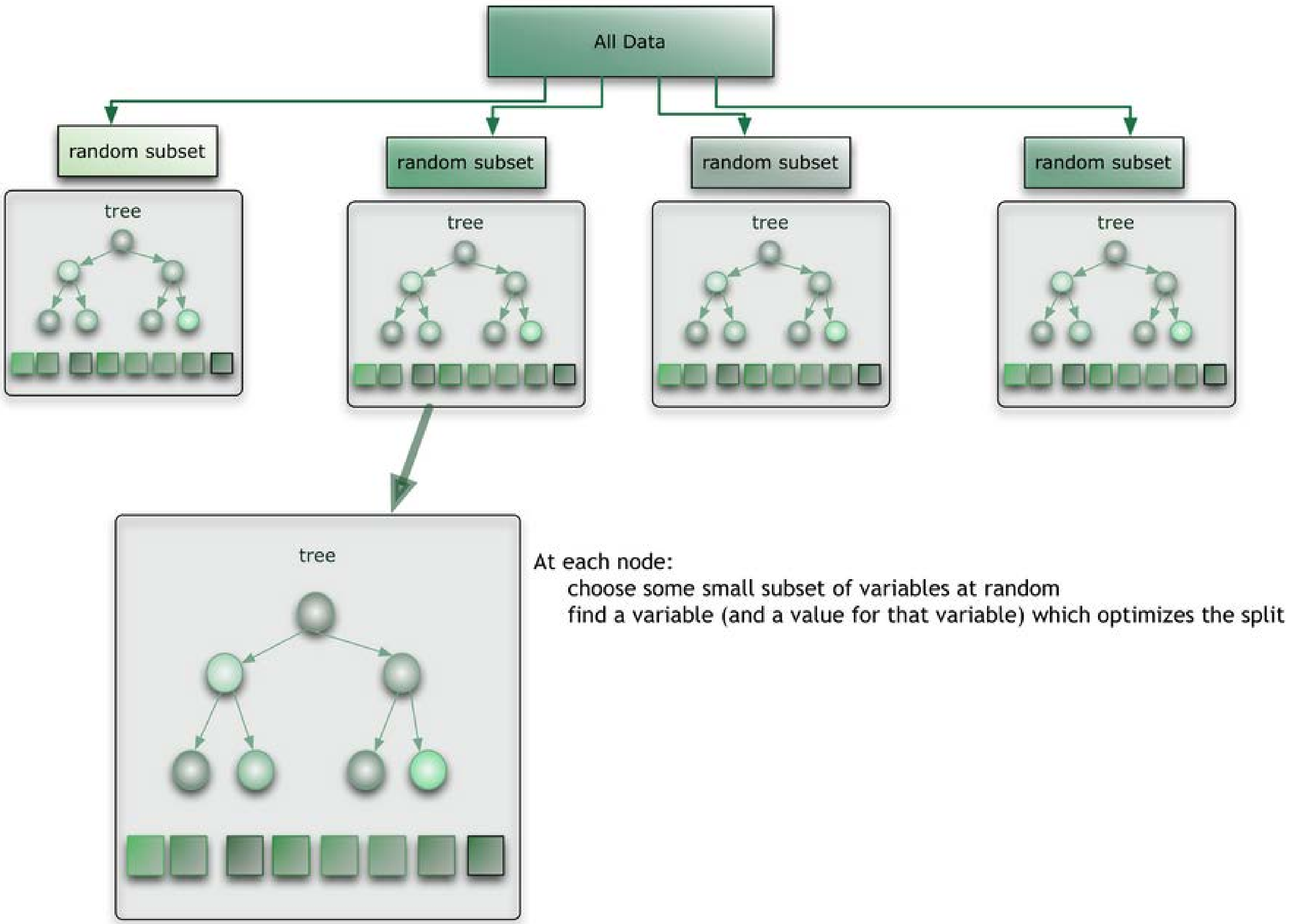
Bringing together different aspects to understand the magnitude of **hydro-political interactions**

Table A1
Descriptive statistics of the data used in the analysis.

Group / Sub-group Name	Description	Abbreviation	*Unit*	Mean	SD	Min	Max	Spatial resolution	Ti
Biophysical									
Falkenmark index	Per capita water available including upstream flow	*Falkenmark_upst*	*m^3 $year^{-1}$*	52,816	80,549	146	904,414	Grid-cell	Y
Precipitation	Total precipitation	*TOT_Precip*	*mm $year^{-1}$*	1,028	596	31	4,971	Grid-cell	Y
	Minimum precipitation	*MIN_Precip*	*mm $year^{-1}$*	764	607	0	4,910	Grid-cell	Y
	Standard Precipitation Index	*SPI_12*	–	−2.5	1.66	−10.8	1.7	Grid-cell	Y
Temperature	Average temperature	*AVG_Temp*	*°C*	16.36	8.86	−12.81	30.02	Grid-cell	Y
	Maximum temperature	*TempMAX*	*°C*	20.01	8.44	−10.51	33.68	Grid-cell	Y
	Minimum Temperature	*TempMin*	*°C*	9.95	10.68	−26.39	28.79	Grid-cell	Y
	Temperature variation	*Temp_delta*	*°C*	3.21	3.71	0	25.69	Grid-cell	Y
	Seasonal variability	*Temp_seasonal_var*	*Stand. dev.*	2.93	2.51	0.03	15.85	Grid-cell	Y
Socioeconomic									
Population	Population density	*Pop_density*	*People $sqkm^{-1}$*	67.62	89.30	0	1,433	Grid-cell	Y
	Share of rural population	*Rural_pop*	*%*	49.42	19.52			Country	Y
GDP	Per capita Gross Domestic Product	*GDP*	*2005 USD*	8,659	10,013	313	59,384	Country	Y
Agricultural dependency of the economy	Agricultural share of the GDP	*Agriculture*	*%*	17.60	12.92	0	61.96	Country	Y
Institutional development and quality	Worldwide Governance Indicators (WGI)	*Governance_ind*	*Normalized value (range: -2.5/+2.5)*	−0.274	0.83	−1.939	1.910	Country	Y
Power imbalance	Composite Index of National Capability	*cinc_mean*	*Normalized value (range: 0/1)*	0.010	0.021	0	0.136	Country	Y
Previous collaboration	Number of bi-or multi-lateral water treaties	*IFTD_treaties*	*number*	17.84	15.61	1	95	Country/ basin	Y
Topography									
Flow accumulation	% of the flow accumulated in the country	*flow_acc*	*%*	0.436	0.31	0	1	Country/ basin	N
Territorial imbalance	Difference of national territory in the basin	*area_diff*	*'000 km^2*	190.8	455.4	0	3,739	Country/ basin	N
Others									
Time trend	Time trend variable	*year*	–	–	–	–	–		Y

Toulouse School of Economics

Statistical modeling: Machine Learning approach (random forest regression algorithm)



Statistical modeling: Machine Learning approach (random forest regression algorithm)

- RF regression algorithm
  - Classification and Regression Tree (CART) based tool that involves an ensemble of regression trees (Breiman, 2001).
  - Iterative process with a regression model fit using a subset of the input data and a portion of the independent variables, are then averages(Breiman, 1994).

- The RF regression algorithm procedure
  - A random subset of the training data is drawn (each tree is trained using about 63%, ~2/3, of the initial observations);
  - For each of the bootstrapped subsets, a tree is grown by recursively repeating three actions: select a random subset of the independent variables; calculate the best variable/split among m variables; generate two sub-nodes
  - Aggregate the generated trees in an ensemble and calculation of the overall MSE (Hastie et al., 2009).

Toulouse School of Economics

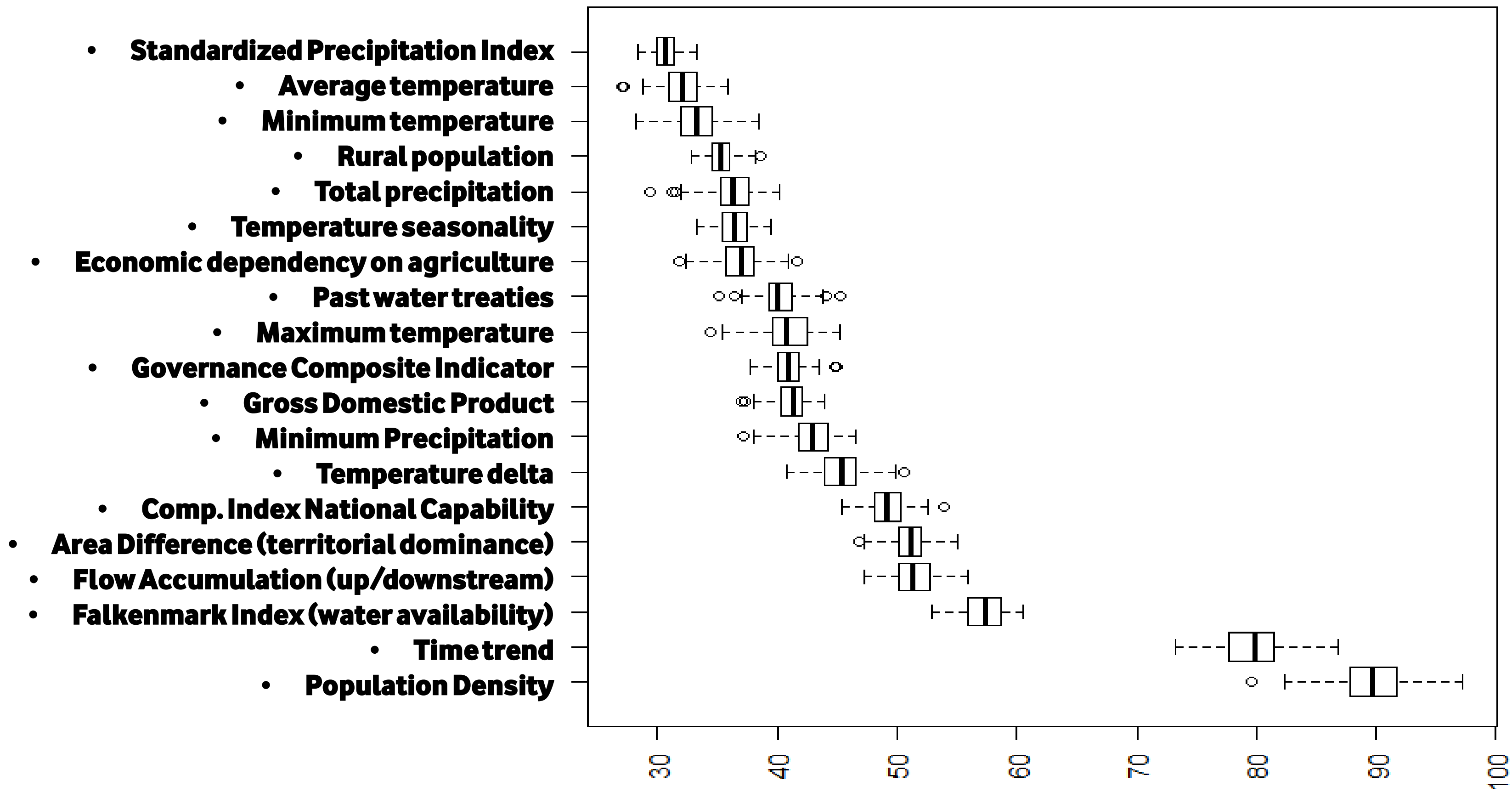
Random forest regression algorithm: Implementation & Results

- The RF model was trained using the entire set of observations
  - Each of the observations reports the logarithmic transformation of the number of hydro-political interactions for a specific dyad of countries (749 country dyadic combinations considered in the final panel) in a specific river basin (260 transboundary basins included) for a specific year (11 years).
  - Of the final 11801 observations considered, 10062 reported no water interactions, while 1739 at least 1 interaction in the combination BCU/year.
- Goodness of fit of the model
  - The overall RF model was found to explain about 70% of the variation

Toulouse School of Economics

Factors ranking

Classification of the driver's relative importance in determining the occurrence of events and their intensity



Factors ranking

- Classification of the driver's relative importance in determining the occurrence of events and their intensity:

  - Population Density
  - Water availability
  - Territorial and military hegemony
  - Socio-economic factors
  - Climate

Non-linear relationships between covariates and probability of water hydro-political interactions

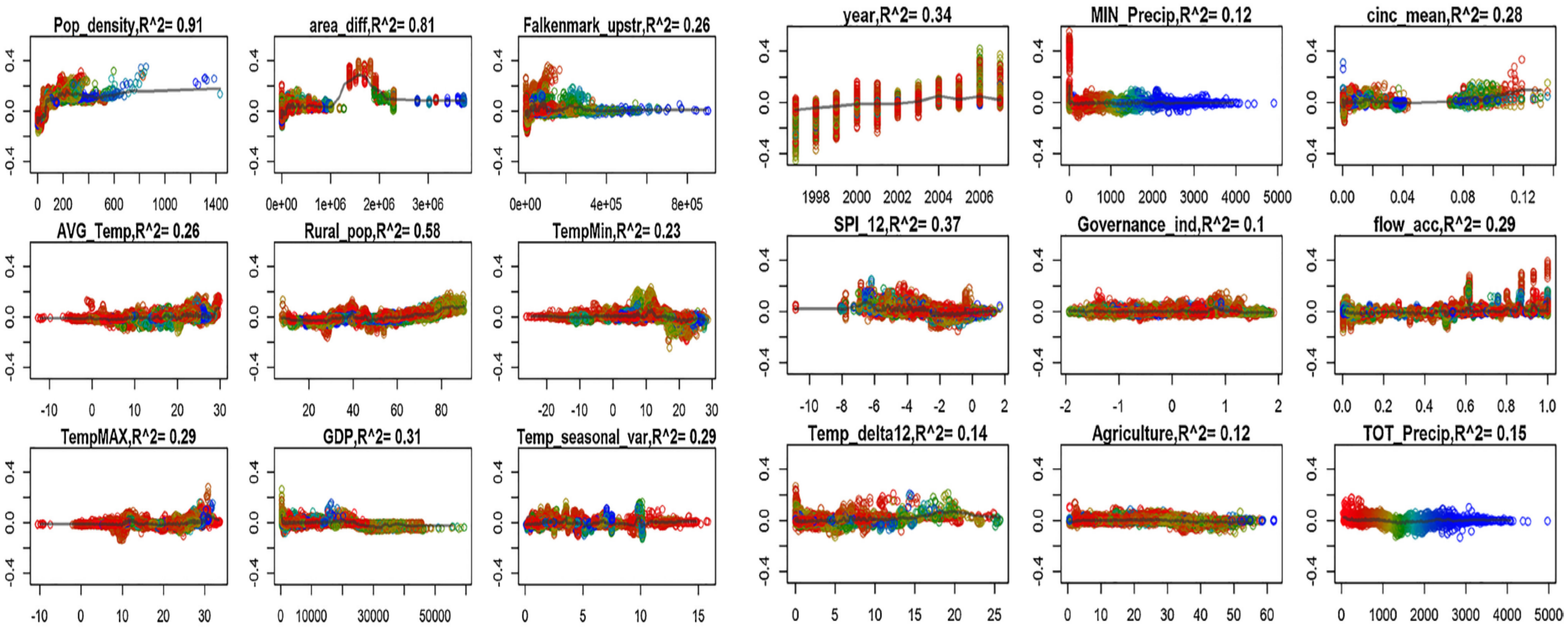
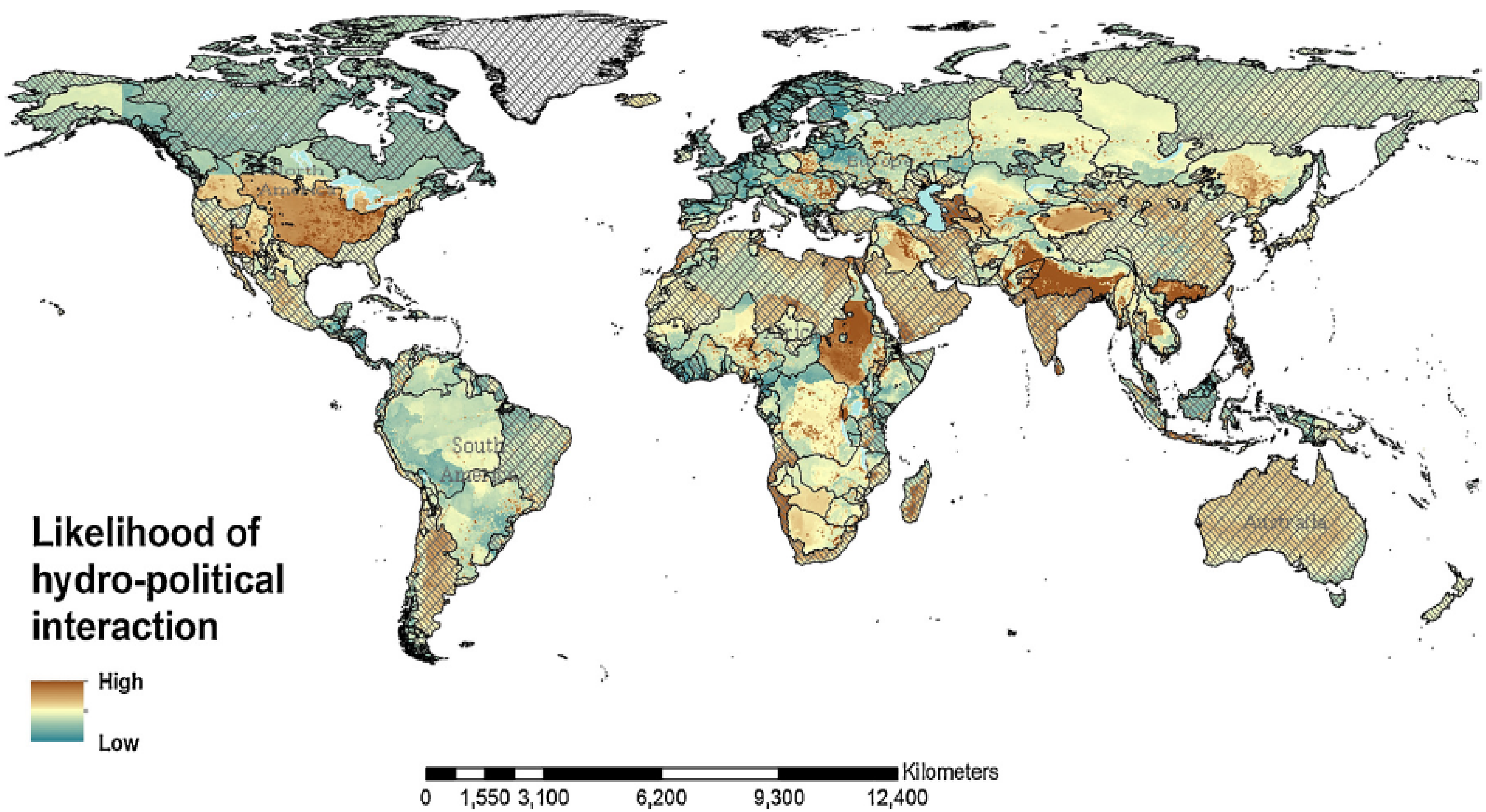
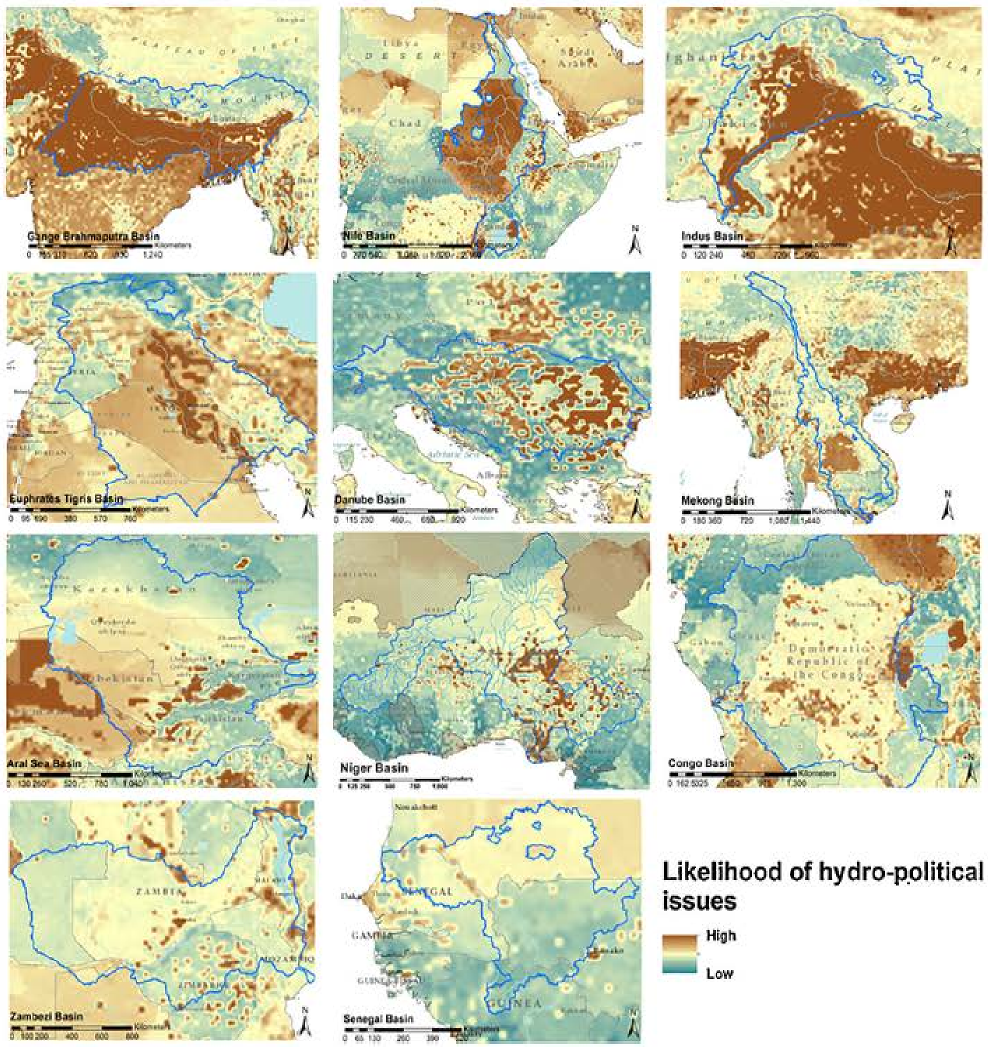


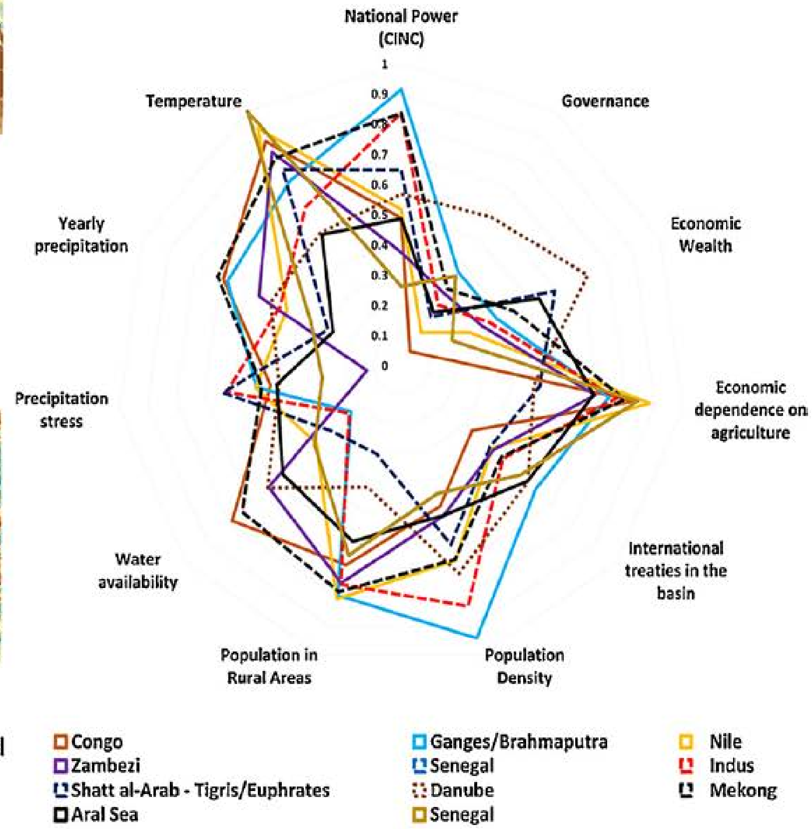
Fig. A4. Partial Dependence plots. Y-axis indicates the cross validated contributions due to the explanatory variable (change in likelihood of hydro-political interactions due to changes in variable), X-axis indicates variable value. Colors indicate the mutual interactions between variables, while the coefficient of determination on top of the boxes indicates the goodness of fit of the trend line (Welling et al., 2016).

Model application to calculate the likelihood of hydro-political interactions under current conditions – Global analysis



Model application to calculate the likelihood of hydro-political interactions under current conditions – Selected IRB





External validy: likelihood of hydro-political Interactions versus WARICC water events

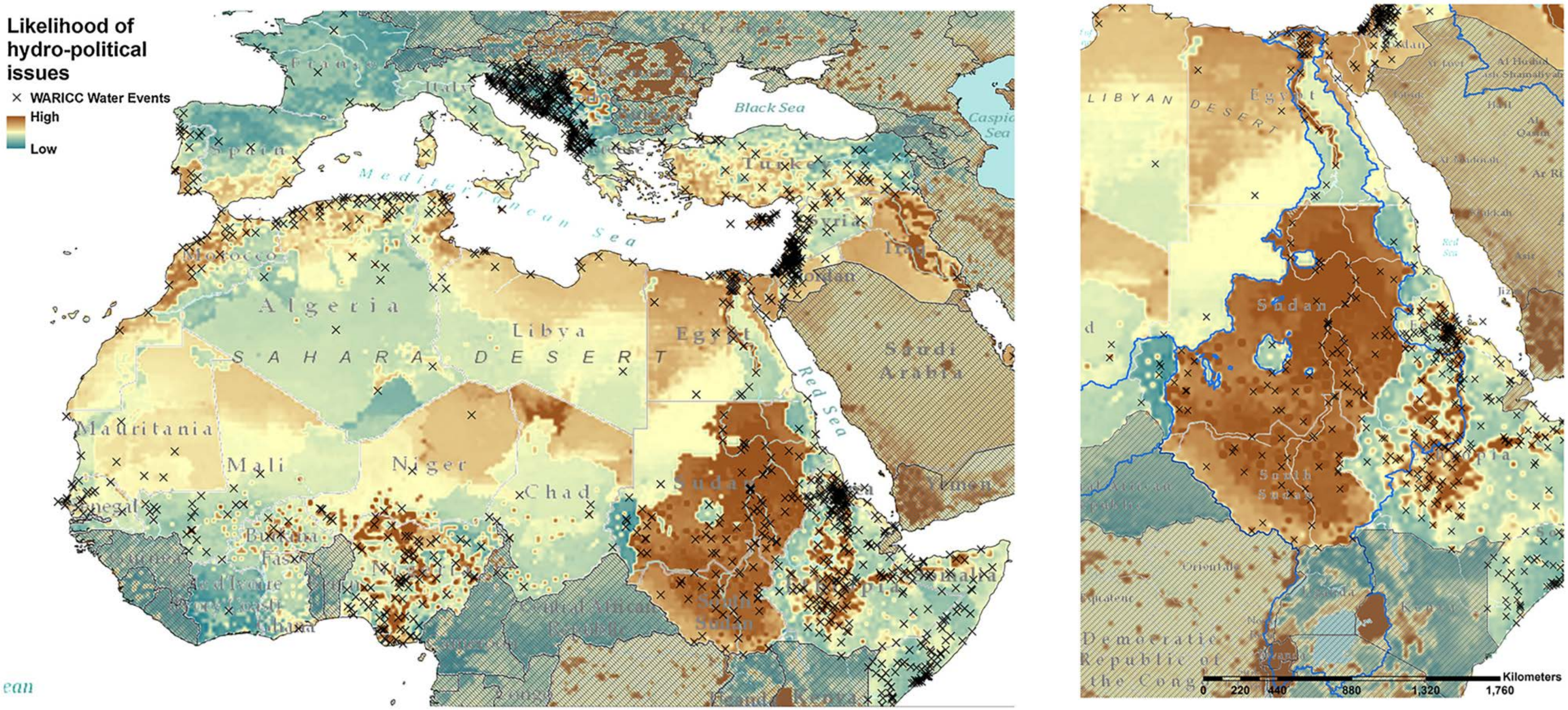


Fig. A6. Comparison between water events reported in the WARICC database between 1997 and 2009 (Bernauer et al., 2012a) and the likelihood of hydro-political interactions presented in this study (shaded areas are not considered in the WARICC database).

Toulouse School of Economics

Model application to calculate the likelihood of hydro-political interactions under future conditions – Global analysis

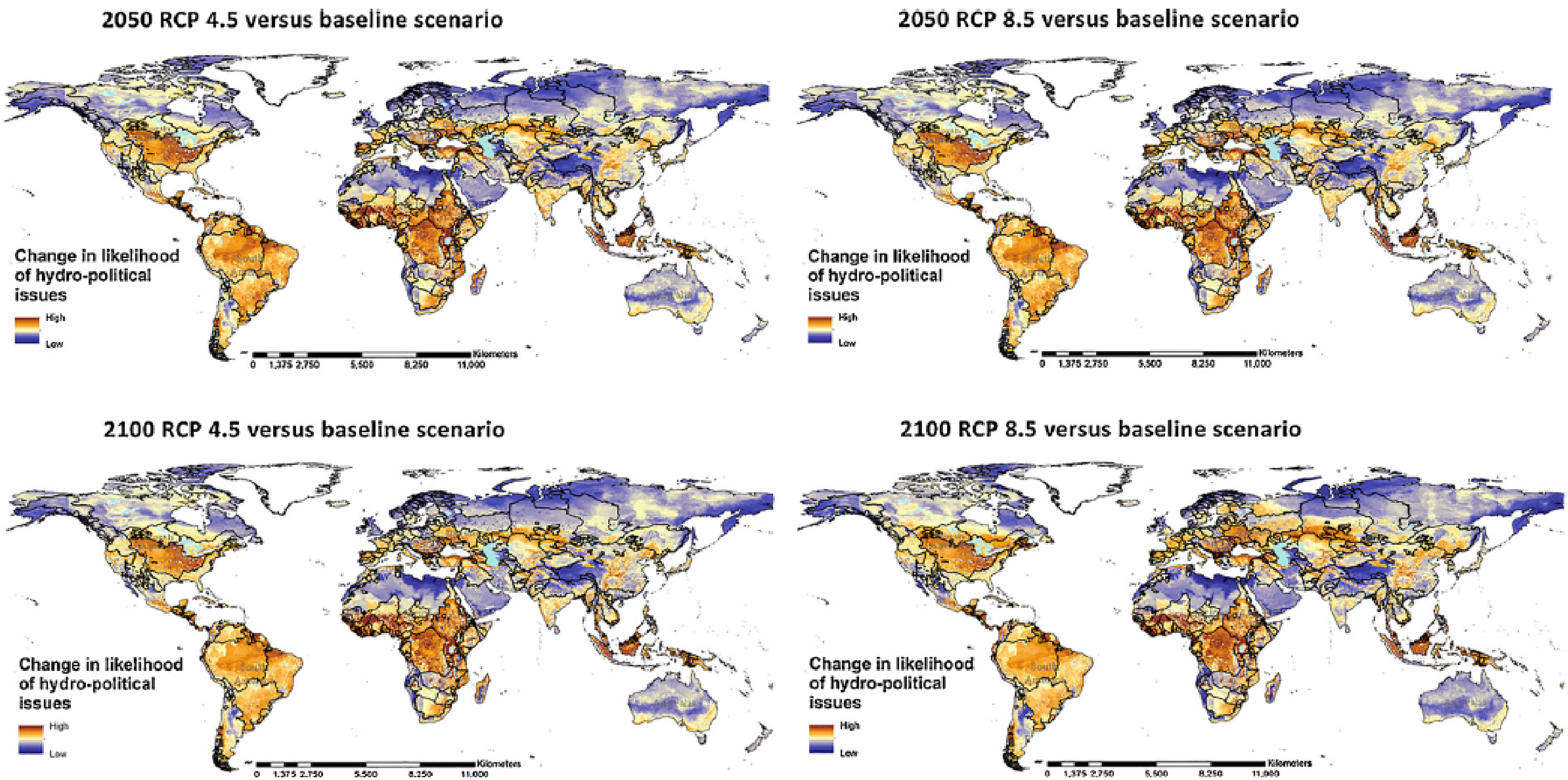


Fig. 3. Change in the likelihood of hydro-political issues considering the four future climate change and population scenarios respect to the baseline

Model application to calculate the likelihood of hydro-political interactions under future conditions – Global analysis

	2050 RCP 4.5		2050 RCP 8.5		2100 RCP 4.5		2100 RCP 8.5	
	Avg % change (Min / Max)	St. Dev	Avg % change (Min / Max)	St. Dev	Avg % change (Min / Max)	St. Dev	Avg % change (Min / Max)	St. Dev
Globe	36.4 (-72/+5944)	56.3	37.1 (-71.5/+5861)	56.9	39.3 (-76.5/+5120)	60.9	46.8 (-69.9/+5235)	67.5
Transboundary basins (all)	74.9 (-61/+5944)	66.7	76.2 (-61/+5861)	97.3	80.7 (-66/+5120)	72.1	95.3 (-57/+5235)	79.4
Lake Chad	77.2 (+12.8/+439)	48	76.7 (+11.7/+439)	48.3	85.7 (+10.9/+567)	67.3	78.4 (-4.2/+557)	64.4
Congo	70.9 (-13.7/+547)	71.6	71 (-12/+546)	70.9	78.1 (-4.6/+601)	75.7	83.3 (-3.6/+514)	72.7
Niger	64.1 (-2.3/+346)	50.6	62.3 (-3.6/+333)	47.9	76 (-3/+378)	68.8	66 (-8.1/+339)	59.5
Nile	43.3 (-35.5/+599)	70.5	43.1 (-35.5/+607)	69.9	45.2 (-30.1/+697)	85	42.4 (-32.5/+734)	84.2
Zambezi	38.9 (-6.4/+321)	34.2	38.5 (-5.8/+312)	33.8	48.4 (-7.7/+418)	47.4	47.1 (-10.2/+342)	43.7
Senegal	36.7 (-5.7/+234)	48.7	36.4 (-5.9/+235)	48.5	45.4 (-5.8/+265)	59.4	41 (-5.1/+247)	51.7
Aral Sea	33.2 (-11.2/+249)	30.1	34.2 (-12.9/+252)	31.1	35.6 (-12.1/+259)	32.1	41.9 (-16.4/+292)	37.4
Euphrates-Tigris	23.1 (-2.5/+349)	46.4	23.5 (-2.3/+364)	48.4	26.5 (-3.5/+446)	50.4	32.5 (-5.3/+563)	59.1
Danube	24.2 (-55/+510)	82.7	26 (-55.5/+518)	84.7	19.2 (-66.1/+555)	88.3	34.7 (-52.3/+651)	110
Indus	12.3 (-27/+169)	26.5	12.5 (-32.5/+168)	26.8	15.3 (-34.9/+224)	30.3	19.1 (-32.3/+262)	35

RCP 4.5 – moderate climate change scenario   RCP 8.5 – severe climate change scenario

Table 1

Summary of estimated change of the likelihood of experiencing hydro-political interactions under four future projected scenarios. Data are presented aggregated per geographic areas or river basins. Values are presented as average (minimum and maximum variation). A more comprehensive table is presented in the Annex (Table A3).

Toulouse School of Economics

Conclusion 1/2

- An innovative analysis of past hydro-political issues in IRBs and their determinants through the application of the Random Forest regression algorithm.
  - factors that are more relevant in determining the hydro-political interactions
  - tool able to map and monitor the evolution of the hydro-political risk over space and time, under specific socioeconomic and biophysical scenarios.

- Factors found to be more relevant in determining hydro-political interactions are:
  - population density,
  - water availability (quantified through the Falkenmark index),
  - upstream/downstream dynamics (represented by the flow accumulation),
  - territorial (area difference) and power imbalance (Composite Index of National Capability – CINC),
  - Climatic conditions.

Toulouse School of Economics

Conclusion 2/2

- Map the spatial distribution of the areas within the basins where water management issues are more likely to rise under current & future conditions.

- Among the basins found to be more likely to experience water issues in this study, some were already identified as basin at risk in previous analyses, namely:
  - Ganges/Brahmaputra, Pearl/Bei Jiang, Nile, Feni (or Fenney), Indus, Colorado, Tarim, Shatt al-Arab - Tigris/Euphrates, Hari, and Irrawaddy.
  - The hereby proposed index adds the possibility to identify the most critical areas within the basin boundaries

- Next: From hydro-political interactions towards cooperation and conflicts. Make the distinction between episodes of cooperation and dispute over water

Want to learn more? Paper in open access

Global Environmental Change 52 (2018) 286–313

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

ELSEVIER

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

Check for updates

F. Farinosi[a,*], C. Giupponi[c], A. Reynaud[b], G. Ceccherini[a], C. Carmona-Moreno[a], A. De Roo[a], D. Gonzalez-Sanchez[a], G. Bidoglio[a]

[a] *European Commission, DG Joint Research Centre, Ispra, Italy*
[b] *Toulouse School of Economics - National Institute for Research in Agriculture (INRA) – University of Toulouse Capitole, Toulouse, France*
[c] *Department of Economics, Venice Centre for Climate Studies (VICCS), Ca' Foscari University of Venice, Venice, Italy*

Arnaud Reynaud gratefully acknowledges the financial support of the Research Chair "Finance Durable et Investissement Responsable" and the Research Chair Amundi.

Toulouse School of Economics

Thank you.

Arnaud Reynaud
Arnaud.reynaud@inra.fr
Arnaud.reynaud@tse-fr.eu