Collaboration for Environmental Evidence

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Systematic Review No. *CEE* 10-010

WHAT IS THE EVIDENCE THAT SCARCITY AND SHOCKS IN FRESHWATER RESOURCES CAUSE CONFLICT INSTEAD OF PROMOTING COLLABORATION?

Draft Review

Appendices

Lead Reviewer: Victoria Johnson

Postal Address: **nef** (the new economics foundation), 3 Jonathan Street, London, SE11 5NH

E-mail Address: victoria.johnson@neweconomics.org

Telephone: +44(0)20 7820 6300

Fax: +44(0)20 7820 6301

Appendices

Appendix A – Köppen-Geiger Climate Classification

Arid, semiarid and dry subhumid hydroclimates (desert, savannahs and steppe ecosystems): These zones are characterised by extreme variability in rainfall such as few rainfall events, high-intensity storms, and high frequency of dry spells and droughts.
Figure 1shows a world map of the Köppen-Geiger Climate Classification. As we were unable to source the raw data for this map, the image was enlarged to A3 size in order to resolve the grid. Countries wholly or partially falling within BWk, BWh, BSk or BSh were considered. **Error! Reference source not found.** shows nations that fell into this category.

Figure 1: World Map of the Köppen-Geiger Climate Classification (Kottek et al., 2006)

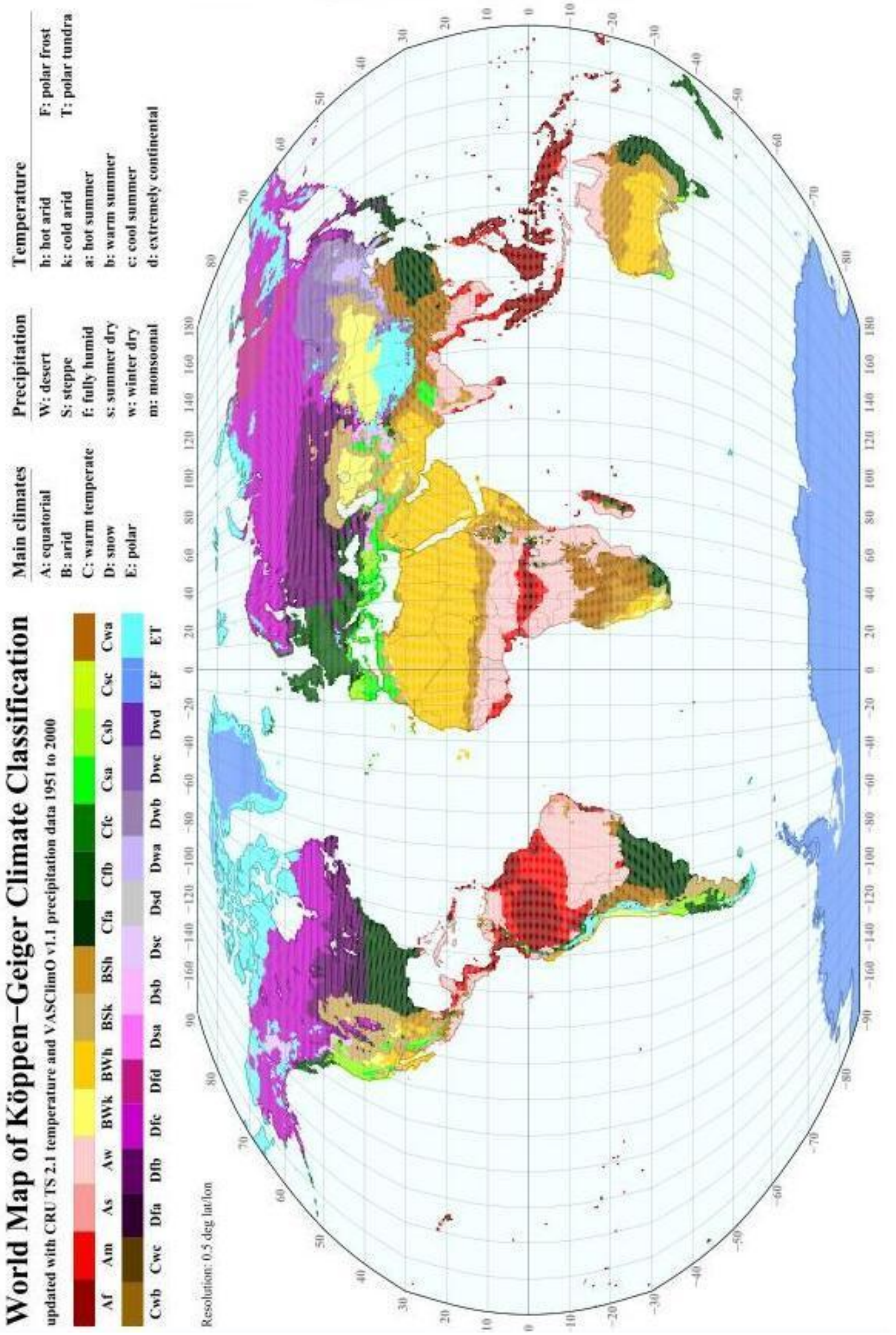

Table 1: Nations wholly or partially classified as arid or semi-arid according to the World Map of the Köppen-Geiger Climate Classification (Kottek et al., 2006)

Algeria
Afghanistan
Angola
Argentina
Australia
Bolivia
Botswana
Brazil
Burkina Faso
Chad
China
Egypt
Ethiopia
Iran
Iraq
Israel
Jordan
Kazakhstan
Kenya
Kyrgyzstan
Lesotho
Libya
Mali
Mauritania
Mexico
Mongolia
Morocco
Mozambique
Namibia
Niger
Oman
Pakistan
Palestine
Peru
Saudi Arabia
Somalia
South Africa
Sudan
Swaziland
Syria
Tajikistan
Tanzania
Tunisia
Turkmenistan
United States (western

half)
Uzbekistan
Western Sahara
Yemen
Zambia
Zimbabwe

Appendix B – Strategy for electronic databases

B.1 Search terms and first results

Preliminary searches were carried as part of a scoping exercise. These aimed to test the relevance of key terms and refine the search strategy. Exposure and outcome terms and their synonyms were identified from our scoping knowledge map and in discussion with the review team keywords and their synonyms identified from our knowledge map. These terms (see Table 2) were then tested using one of the largest databases: Web of Science (ISI Web of Knowledge).

Table 2: Initial search terms

	Search terms (searches were carried out using Boolean operators and wildcards)
Exposure terms	water*, riparian*, aquifer*, aqua*, dam, dams, hydrolog*, hydroelectric*, groundwater, drought*, river*, lake*, stream, streams, reservoir*, flood*, irrigat*, rain*, baseflow*, precipitation, fresh*, basin*, flow, drylands
Outcome terms	conflict*, dispute*, insurgen*, war*, violen*, securit*, terror*, strife, peace*, govern*, coercion, cooperat*, "co-operat*", collaborat*, collective, geopolitic*, "international relation*" allocat*, distribut*, shar*, mediat* governance, treaty, treaties, agreement*, manag*

The refining of the search terms was an iterative process. Each term was tested for its relevance and either rejected or refined. For example, "rain*" became three separate terms rather than a single one with wildcard. Exposure terms were checked first and outcome terms second. All searches were limited to articles published from 1990 onwards. Terms were searched in TOPIC (title, abstract – when available - and keywords) and the first 100 articles were screened to determine usefulness of the term (after sorting by relevance). The results of the trial are outlined in Table 3.

Table 3: Results of trial searches in Web of Science

Trial	Number of articles	Term(s) tested	Search syntax and changes	Comments
1	> 100,000	All terms	Complete initial search	Large number of unrelated articles and volume of hits too high.
2	604	Rain, rains, rainfall	Change rain* to rain, rains and rainfall: (rain OR rains or rainfall) AND (conflict* OR cooperat*)	A few relevant articles identified in the first 50 hits. Included in final search.
3	3	Baseflow*	baseflow* AND (cooperat* OR conflict*)	No relevant articles. Excluded from final search.
4	633	Precipitation	precipitation AND (cooperat* OR	Large number of unrelated articles. Excluded from

Trial	Number of articles	Term(s) tested	Search syntax and changes	Comments
			conflict*)	final search.
5	1,049	Basin	basin AND (cooperat* OR conflict*)	As above.
6	255	Flood	flood AND (cooperat* OR conflict*)	As above.
7	1,290	Fresh*	fresh*	As above.
8	5,151	Flow	flow	As above.
9	356	Hydrolog*	hydrolog*AND (cooperat* OR conflict*)	As above.
10	62	Hydroelectric*	hydroelectric* AND (cooperat* OR conflict*)	No relevant articles. Exclude from final search.
11	547	Irrigat*	irrigat* AND (cooperat* OR conflict*)	As above.
12	977	Stream, streams	(stream OR streams) AND (cooperat* OR conflict*)	As above.
13	785	Aqua*	aqua* AND (cooperat* OR conflict*)	As above.
14	182	Aquifer	aquifer AND (cooperat* OR conflict*)	As above.
15	353	Groundwater	groundwater AND (cooperat* OR conflict*)	As above.
16	777	Dry	dry AND (cooperat* OR conflict*)	As above.
17	38	Dryland	dryland AND (cooperat* OR conflict*)	As above.
18	274	Dam, dams	(dam OR dams) AND (cooperat* OR conflict*)	Relevant articles in the first 50 hits. Included in final search.
19	442	Reservoir*	reservoir* AND (cooperat* OR conflict*)	As above.
20	828	Lake*	lake AND (cooperat* OR conflict*)	As above.
21	10,935	**Reduced list of exposure terms**	(water* OR riparian* OR dam OR dams OR drought* OR river* OR lake* OR reservoir* OR rain OR rainfall OR rains) AND (cooperat* OR conflict*)	As above.

Trial	Number of articles	Term(s) tested	Search syntax and changes	Comments
22	49	Coercion	coercion AND (newly reduced exposures)	No relevant articles. Excluded from final search.
23	123	Geopolitic*	geopolitic* AND (reduced exposures)	As above.
24	7,048	Rational*	rational* AND (reduced exposures)	As above.
25	763	Disput*	disput* AND (reduced exposures)	Relevant articles in the first 50 hits. Included in final search.
26	21	Insurgen*	insurgen* AND (reduced exposures)	As above.
27	2,797	Securit*	securit* AND (reduced exposures)	As above.
28	26	Strife	strife* AND (reduced exposures)	As above.
29	224	Terror*	terror* AND (reduced exposures)	As above.
30	19,121	Govern*	govern* AND (reduced exposures)	As above.
31	23,175	Collecti*	collecti* AND (reduced exposures)	As above.
32	54	"International relation*"	"International relation*" AND (reduced exposures)	As above.
33	40,760	Agreement*	agreement* AND (reduced exposures)	As above.
34	8,445	Allocat*	allocat* AND (reduced exposures)	As above.
35	>100,000	Distribut*	distribut* AND (reduced exposures)	High volume of hits and no relevant articles in the first 100 hits. Exclude the term in final search.
36	2,769	Collaborat*	collaborat* AND (reduced exposures)	As above.
37	2,317	Collaboration, collaborative	(collaboration OR collaborative) AND (reduced exposures)	Little difference with previous search. Still no relevant articles. Potentially relevant ones seem to focus on collaboration in industrialized countries and in planning policies and governance. Checked by doing a title search before excluding. Exclude the term in final search.
38	160	Collaborat*	collaborat* AND (reduced exposures) in	Little difference with previous search. Excluded

Trial	Number of articles	Term(s) tested	Search syntax and changes	Comments
			TITLE	from final search.
39	848	Violen*	violen* AND (reduced exposures)	No relevant articles. Excluded from final search.
40	24,117	Shar*	shar* AND (reduced exposures)	High volume of hits and no relevant articles in the first 100 hits. Checked with more specific terms such as share, shared, and sharing.
41	9,341	Share, shared, sharing	(share OR shared OR sharing) AND (reduced exposures)	No relevant articles. Excluded from final search.
42	26,508	Mediat*	mediat* AND (reduced exposures)	As above.
43	357	Treaty, treaties	(treaty OR treaties) AND (reduced exposures)	Relevant articles in the first 50 hits. Included in final search.
44	820	Peace*	peace* AND (reduced exposures)	As above.
45	41,598	Agreement*	agreement* AND (reduced exposures)	High volume of hits, but relevant articles in the first 100 hits. A few relevant articles also include the word 'conflict'. Modify search to exclude 'conflict'.
46	41,117	Agreement*	agreement* AND (reduced exposures) NOT (conflict* OR cooperat*)	High volume of hits and no relevant articles in the first 100 hits. Checked with title only search.
47	80	Agreement*	agreement* AND (reduced exposures) (in title)	Relevant articles in the first 100 hits. Modified search to exclude 'conflict*', 'cooperat*' and 'peace'
48	73	Agreement*	agreement* AND (reduced exposures) NOT (conflict* OR cooperat* OR peace*) (in title)	Previously relevant articles no longer return because of exclusion of terms 'conflict', 'cooperat*', 'peace'. No relevant articles. Exclude from final search.
49	71,868	Manag*	manag* AND (reduced exposures)	High volume of hits, many related to water management for agriculture. Modified search to include specific types of management such as "water resource management"
50	8,964	Several types of	("water management"	High volume of hits. A few

Trial	Number of articles	Term(s) tested	Search syntax and changes	Comments
		management	OR "river management" OR "basin management" OR "water resource management" OR "watershed management") AND (reduced exposures)	relevant articles which also include the terms 'conflict' or 'cooperation'. Modified search to exclude these terms.
51	8,580	Several types of management	("water management" OR "river management" OR "basin management" OR "water resource management" OR "watershed management") AND (reduced exposures) NOT (conflict* OR cooperat* OR peace*)	Many returns, with no relevant articles in first 100 hits. Modify search to find other types of management which might be relevant
52	55,445	Several types of management	management AND (reduced exposures) NOT ("water management" OR "river management" OR "basin management" OR "water resource management" OR "watershed management")	No relevant articles. Exclude 'management' and other composite terms from final search.
53	9	Hydro-political	hydro-political AND (reduced exposures)	No relevant articles. Exclude from final search.
54	**20,159**	**All terms**	**(reduced exposures) AND (newly reduced outcomes)**	**Many relevant articles in first 100 articles, and manageable number of total returns.**

The final trial produced a large but manageable number of articles for initial screening.

B.2 Retrieved citations

Search strategies were modified according to each search engine and database included in the review. Table 4 outlines the total number of articles returned from each database searched as well as modifications to the syntax imposed by the variations or limitations of each database.

Table 4: Retrieved citations

Database	Number of articles	Years covered by search	Search strategy used	Comments
Web of Science	20,159	1990-2010	(all outcomes) AND (all exposures)	
ScienceDirect	4,868	1990-2010	(all outcomes) AND (all exposures)	
African Journals Online	53	2003-2010	(all outcomes) AND (all exposures)	Database started in 2003. Title only search.
Directory of Open Access Journals	157	n/a	Conflict AND water (in abstract); cooperation AND water (in abstract)	Limited search capability. Searches were carried out by pairing one exposure with one outcome.
JSTOR	72	1990-2010	(all outcomes) AND (all exposures)	Full search capabilities. First 72 articles were imported. All others were not relevant.
SAGE	101	1990-2010	Conflict AND water (in abstract); cooperation AND water (in abstract)	Limited search capabilities with 'add row' function.
SCOPUS	512	1990-2010	(all outcomes) AND (all exposures)	Full search capabilities.
Adelphi	12	21	Conflict AND water (in abstract); cooperation AND water (in abstract)	Limited search capabilities.
EBSCO-Econlit	2000	n/a	(all outcomes) AND (all	Copied the first 2000 references

Database	Number of articles	Years covered by search	Search strategy used	Comments
			exposures)	to *Mendeley*. Remaining articles were found to be irrelevant.
Geobase	205	1990-2010	(all outcomes) AND (all exposures)	Full search capabilities.
International Bibliography Of the Social Sciences (IBSS)	1196	Earliest-Current	(all outcomes) AND (all exposures)	As above.
SciDev.net	118	n/a	Conflict AND water; cooperation AND water	Limited search capability. Searches in 'key documents'
Woodrow Wilson International Centre for Scholars	7	n/a	Conflict AND water; cooperation AND water	Limited search capability. Searches in 'Publications'
UNEP, ODI, World Bank	245	1990-2010	Water in TITLE AND all outcomes in TEXT	Used Google Scholar for UNEP documents. Limited search capabilities.
Web search	540	1990-2010	Conflict AND water; cooperation AND water	http://www.alltheweb.com http://www.scholar.google.com http://www.google.com http://www.dogpile.com
Pacific Institute's Water and Conflict Bibliography	31	n/a	Conflict AND water; cooperation AND water	
Eldis	118	n/a	Conflict AND water; cooperation AND water	

Appendix C – Coding Tool

Generic	
Identification of report	• Citation (author, date, title, editors (if book section), journal (volume, pages) or publisher (city: institution) • Contact • Hand search • Electronic database (e.g. WoK) • Unknown
What kind of printed material does it concern?	• Book • Journal article • Report/working paper • Other (please specify)
What is the status of the report?	• Published • In press • Unpublished (including ongoing project, communication from author) • Conference presentation

Methodological	
What is the purpose of the research?	
What type of methods does this research study report using? (please specify)	

Review specific	
Time frame (please specify)	
Spatial scale	• **Intracommunity** -Where social interactions of some aspect of water may occur over a very small area between members of the same community • **Intercommunity -** Representing a slightly larger scale, where all or most of the individuals within each community may present a united front in their interactions with a neighbouring community • **n>2** - Transboundary conflict involves more than 2 states • **n=2 -** Transboundary conflict involving 2 states • **Urban-Rural** • **Aggregate national level** • **Interstate** (not transboundary rivers)

Population focus (select all that apply)	• **Individuals** • **Households** • **Communities** *Of place* • **Local/ regional government** • **State** • **Private sector** *Please specify which sector(s)* • **Civil society** *civilians* • **Military**
Theoretical framework (please select all that apply)	• Neo-Malthusian • Cornucopian • Common Property Management • Realist • Neoliberal • Other (please specify) • **Unclear** • **None**
What country/countries were studied (Please select all that apply and specify which nations)	• **Global** • **Africa** • **Asia** • **Central America** • **Eastern Europe** • **European Union** • **Middle East** • **North America** • **Please specify (territory or state)** • **Oceania** • **Central America** • **South America** • **The Caribbean**
Dependent variable measured *Please specify measure used and how measured (e.g. from existing dataset; observation; participant views)*	• **Cooperation** *"A situation where there is currently an absence of conflicting interests between two actors, or else where they are regularly resolved through non-violent "mechanisms'* • **Non-violent conflict** *Demonstrations, strikes, claims (please specify)* • **Violent conflict** *'situations of tense confrontation between armed forces, engaging in threats and possible skirmishes, but without significant and sustained force' or 'conflicting interests are normally fought over through violent and coercive military means'* • **Other** *please specify*
Independent variable	• **Meteorological variable**

measure (freshwater) *Please select all the apply*	*Measures changes in variation in rainfall (specify dataset)* • **Anthropogenic** *River flow reduced due to daming, diversion, increased consumption etc(please specify)* • **Natural -changes to river flow** *Changes in river flow are due to natural causes (e.g. not due to daming or increased upstream withdrawls)* • **Water stress index** *Uses a water stress index that uses only physical parameters (e.g. does not include social parameters) please specify index and dataset name* • **Social water stress index** *Please specify index used and parameter* • **Threshold indicator** *e.g. Drought. Please specify dataset* • **Groundwater measure** • **Other** *Please specify*
Other explanatory variables *E.g. in addition to a freshwater scarcity measure. Please specify measure(s)*	*Please specify measure(s)*
Account of result	*Brief summary of conclusion < 50 words. Tick box to confirm completion*

Appendix D - Systematic map

D.1 Generic details of 48 included studies

Study	**Identification of report**	**Type of publication**	**Status of report**	**Study purpose**	**Time-frame**	**Research methods**
Araral (2009)	EBSCO	Journal article	Published	Examines factors that most influence the likelihood of collective action among users of a common resource pool. Irrigation association is the unit of analysis.	Multivariate data set from 2002; ground-truthing observations 2003-2005	Quantitative • Statistical associations: *OLS, Logit, time series.*
Bardhan (2000)	Web search	Journal article	Published		Not specified	Quantitative • Statistical: associations: *Logit*
Bernauer et al (2010)	Contact	Working Paper/ Report	Published	Explore the link between climate, economic growth and armed conflict.	1950-2004	Quantitative • Statistical associations: *2SLS, time series.*
Bogale & Korf (2007)	Electronic dataset: EBSCO	Journal article	Published	Investigates major socioeconomic and demographic characteristics of households that influence their choice of	Does not specify	Quantitative • Statistical associations: *Logit* Qualitative methods

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
				institutional arrangement.		• semi-structured interviews: *semi-structured group interviews* • Ethnography: *informal surveys*
Brochmann & Gleditsch (2006a)	Electronic dataset: Web search	Working Paper/ report	Published	Explores the conditions under which a water treaty seems to exist in a dyad, and the relationship between water related events and the signing of treaties.	1820-2002	Quantitative • Statistical associations: *Econometric, logit regression, dyad-year is unit of analysis*
Brochmann & Gleditsch (2006b)	Electronic dataset: Web search	Working Paper/ Report	Published	Dyads are the unit of study	1880-2000 & 1975-2000	Quantitative • Statistical associations: *Multivariate analysis. Gravity model is used as a baseline and additional control variables are included from an earlier study of shared rivers and conflict.*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
Brochmann & Hensel (2008)	Electronic dataset: Web search	Working Paper/ Report	Published	Examine the management of internationally shared rivers to explore the conditions states are most likely to try and solve ongoing river disputes. Dyad-year is the unit of analysis.	1900-2001	Quantitative • Statistical associations: *Multivariate analyses (Heckman probit analysis). Control for relative capabilities (CINC, from ICoW).*
Buhaug & Theisen (2010)	Contact	Book	Published	Assesses the impact of drought on civil war in SSA	1960-2004	Quantitative • Statistical associations: *Regression, time series*
Buhaug (2009)	Contact	Journal article	Published	Investigates relationship between environmental shocks (drought, prolonged heat waves) and civil wars in Africa.	1982-2002	Quantitative • Statistical associations: *multivariate regression models*
Burke *et al* (2009)	Electronic dataset: Web of Knowledge	Journal article	Published	Explore the relationship between onset of civil war and country-level varying temperature and precipitation.	1981-2002	Quantitative • Statistical associations: *Regression, time series.*
Burke *et al*	Contact	Working	Published	Explores the incidence of	1981-2002	Quantitative

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
(2010)		Paper/ Report		civil war to country specific deviations from long-term trends temperature and precipitation. Re-examining an earlier paper that linked historical variation of climate to incidence of African conflict.		• Statistical associations: *Regression, time series.*
Dayton-Johnson (2000)	Electronic dataset: ScienceDirect	Journal article	Published	Theoretical model verified by field work to explore the determinants of cooperation in Mexican irrigation societies.	1995-1996	Quantitative • Statistical associations: *Logit, Cross-sectional* Qualitative methods • Ethnography
De Stefano *et al* (2010)	Electronic dataset: Web of Knowledge	Journal article	Published	Surveys hydro political relations over the period 1948-1999 and compares to 2000-2008.	1948-2008	Quantitative • Collects numerical measures: *International basins (from the Transboundary Freshwater Dispute*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
						Database and Atlas of International Freshwater Agreements) scanned for new events. International Water Events listed from year 1999 culled for news sources and keywords. Incidents ranked by intensity along a conflict-cooperation scale used in the International Water Events Database of COPDAB. • Examines relationships: *Relationship between water-related events and level of conflict/cooperation in 1948-1999 compared to 2000-2008*
Dinar (2009)	Electronic dataset: Web search	Journal article	Published	Analysis of cooperative amongst dyads and their associated Water Poverty Index scores.		Quantitative • Statistical associations: *ANOVA*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
Dinar *et al* (2010)	Electronic dataset: DOAJ	Journal article	Published	Explores the impact of water supply variability on 'treaty cooperation' between dyads.	Un-specified	Quantitative • Statistical associations: *Logit, time series.*
Dinar *et al* (2007)	Electronic dataset: EBSCO	Working Paper/ Report	Published	Explores the impact of water scarcity in leading to cooperation between dyads.	1850-2002	Quantitative Statistical associations *OLS, time series.*
Fayankinnu (2005)	Electronic dataset: DOAJ	Journal article	Published	Examines the form/patterns of social conflict generated as a result of water shortage in Akungba-Akoko of Ondo State.	no indication	Quantitative • Structured surveys and/or validated measures • Collects numerical measures Qualitative methods • semi-structured interviews: *in-depth interviews*
Funder *et al* (2010)	Electronic dataset: Web of Knowledge	Journal article	Published	Explores water conflict and cooperation events in Namwala District of Zambia	1995-2007	Qualitative methods • Focus group • semi-structured interviews • Other: *3 in-depth case studies*

Study	**Identification of report**	**Type of publication**	**Status of report**	**Study purpose**	**Time-frame**	**Research methods**
Furlong (2006)	Electronic dataset: Web search	Journal article	Published	Explore the relationship between shared rivers, water scarcity and conflict.	1880-1992	Quantitative • Statistical associations: *Logit, time series.*
Gizelis & Wooden (2011)	Electronic dataset: ScienceDirect	Journal article	In press	Explores the relationship between water scarcity, intrastate conflict and institutions.	1981-2000	Quantitative • Statistical associations: *Simultaneous equations model, time series.*
Gleditsch (2006)	Electronic dataset: IBSS	Journal article	Published	Examines the relationship between shared rivers and interstate conflict.	1880-2001	Quantitative • Statistical associations: *Logit, time series.*
Raju *et al* (2005)	Electronic dataset: *Eldis*	Working Paper/ Report	Published	Aims to determine factors that exert an influence on the existence of organizations.	Not specified	Quantitative • Statistical associations: *Logit* Qualitative methods • Ethnography: *Ethnographic information relating to study villages and their history.*
Hamner	Electronic	Working	Published	Test the impact of	1948-2001	Quantitative

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
(2009)	dataset: Web search	Paper/ Report		drought on the likelihood of water treaty formation between 2 countries.		• Statistical associations: *Cox regression, time series.*
Hauge (1998)	Electronic dataset: Web search	Journal article	Published	Examines relationship between supply-induced scarcity and domestic armed conflict. Also examines impact of scarcity on the severity of domestic armed conflict.	1980-1992	Quantitative • Statistical associations: *Logit; time series, cross-sectional data to verify results.*
Hendrix & Glaser (2007)	Hand search	Journal article	Published	Explore the impact of both long term trends in land degradation, climatic suitability and freshwater availability and short term rainfall triggers on civil conflict onset in Sub-Saharan Africa.	1981-2002	Quantitative • Statistical associations: *Logit, time-series.*
Hendrix & Salehyan (2010)	Electronic dataset: Eldis	Working Paper/ Report	Conference presentation	Explores how deviations from normal rainfall patterns, and extreme events, affect political	1990-2009	Quantitative • Statistical associations: *Econometric, logistic regression: controls for*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
				behaviour and the propensity for individuals and groups to engage in disruptive activities, such as riots.		*regime type, level of development, economic growth, population, population growth and incidence of civil conflict.*
Hensel & Brochmann (2007)	Electronic dataset: Web search	Working Paper/ Report	Conference presentation	Explores the management of shared rivers to examine the conditions under which outbreak of explicit disagreements (river claims) and which of these disagreements are most likely to lead to militarisation.	1990-2001	Quantitative • Statistical associations: *ReLogit (Rate Event Logistic Regression) (King and Zeng, 2001). Argue that standard statistical techniques such as logistic regression produce bias results when used for rare dependent variables.*
Hensel *et al* (2006)	Electronic dataset: IBSS	Journal article	Published	Explores link between resource scarcity (water in this case) and interstate conflict.	1900-2001	Quantitative • Statistical associations: *Logit, time series.*
Kevane & Leslie (2008)	Electronic dataset Web of Knowledge	Journal article	Published	Time series analysis of rainfall data and compares to outbreaks of violence	1942-2002	Quantitative • Examines relationships: *Time series analysis of*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
				(viz. Darfur, 2003).		*rainfall data and compares to outbreaks of violence (viz. Darfur, 2003).*
Levy *et al* (2005)	Contact	Working Paper/ Report	Published	Examines the relationship between conflict and lack of water and deviations from the local normal rainfall conditions.	1980-2002	Quantitative • Statistical associations: *Logistical regression model*
Makepe (2005)	Electronic dataset: EBSCO	Journal article	Published	Study examining the determinants of collective action over water (and grazing) management.	2002	• Structured surveys and/or validated measures: *3 members from each of the 73 borehole syndicates. Collected information on the: structure; function; use and maintenance or water and range resources; range degradation and improvements; causes and extent of disputes over resource use; market accessibility.* Quantitative • Statistical associations:

Study	**Identification of report**	**Type of publication**	**Status of report**	**Study purpose**	**Time-frame**	**Research methods**
						Regression Qualitative methods • semi-structured interviews
Meier *et al* (2007)	Electronic dataset: Web search	Working Paper/ Report	Published	Explores the relationship between rainfall deficiency and violence in the border areas between Uganda, Kenya and Ethiopia.	January 2004 - December 2005	Quantitative • Statistical associations: *OLS, times series.*
Raleigh & Urdal (2007)	Electronic dataset: Web search	Journal article	Published	Using GIS, explores the relationship between land degradation, freshwater availability, population density change and armed conflict.	1990-2004	Quantitative • Statistical associations: *Logit, cross-sectional.*
Stalley (2003)	Unknown	Working Paper/ Report	Published	Explores the relationship between militarised international disputes and environmental variables.	1980-1992	Quantitative • Statistical associations: *Logit, time series.*
Stinnett (2009)	Hand search	Journal article	Published	Explores the features of international river basin treaties and how these	1950-2002	Quantitative: • Statistical associations: *Probit, time series.*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
				institutions arise.		
Theisen (2008)	Contact	Working Paper/ Report	Unpublished	Examines resource scarcity and the incidence of civil armed conflict. Re-examines Hauge and Ellingsen (1998).	1979-2001	Quantitative • Statistical associations: *Logit; time series.*
Theisen (2010a)	Electronic dataset: Eldis	Working Paper/ Report	Published	This study uses a spatially disaggregated dataset for Africa to examine link between onset of civil war and drought.	1960-2004	Quantitative • Statistical associations: *Relogit, Logit, time series.*
Theisen (2010b)	Contact	Working Paper/ Report	Conference presentation	Explores the relationship between armed clashes and scarce natural resources.	1989-2004	Quantitative • Statistical associations: *Relogit, time series.*
Thiesen & Brandsegg (2007)	Electronic dataset: SAGE	Journal article	Published	Explores whether marginalised area experiencing pressure on renewable resources, absolute amount/levels of renewable resource or	2002-2005	Quantitative • Statistical associations: *Logit, cross-sectional.*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
				access to resource available in a country increases the risk of internal conflict.		
Tir & Ackerman (2009)	Electronic dataset: Web search	Journal article	Published	Examines factors that enable or hinder the emergence of formalised river cooperation.	1948-2000	Quantitative • Statistical associations: *Cox regression, time series.*
Toset (2000)	Hand search	Working Paper/ Report	Conference presentation	Explores how the supply of water may be associated with violent conflict between states, on its own or interaction with other factors.	1880-1992	Quantitative • Statistical associations: *Logit, time series.*
Witsenburg & Roba (2002)	Hand search	Journal article	Published	Explores the link between violent conflicts and scarcity of water in Marsabit District, northern Kenya.	1997-2000	Quantitative • Statistical associations: *Correlation between armed incidents and killings and rainfall / rainfall 1-year time lag.* Qualitative methods

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
						• semi-structured interviews • Ethnography: *Historical records.*
Wolf (1998)	Electronic dataset: Web of Knowledge	Journal article	Published	Aims to identify historical indicators of international freshwater conflict and cooperation and create a framework to identify river basins that might have conflicts in the future.	1948-1999	Quantitative • Examines relationships
Wutich (2009)	Contact	Journal article	Published	Examines the design of a water institution and its sustainability during periods of water scarcity in urban Cochabamba	2003-2008	Quantitative • Examines relationships: *Tabulates the relationship between use of tapstand system (distributes groundwater) and community membership (collaboration).* Qualitative methods • Semi-structured interviews: *Household interviews with*

Study	Identification of report	Type of publication	Status of report	Study purpose	Time-frame	Research methods
						community and non-community members.
Yoffe (2003)	Contact	Journal article	Published	Explored the impact of a number of factors including water stress on conflict/cooperative outcomes in international river basins.	1948-1999	Quantitative • Statistical associations: *Regression, time series, two-sample t-tests.*

D.2 Review specific details by scale of analysis

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
Araral (2009)	Intracommunity	Individuals: *Farmers within irrigation associations*	Asia: *Philippines*	Common resource management theory. Collective action outcomes are shaped by the incentive structure faced by the players which is in turn affected by the context they face. The context is defined by the physical characteristic of the resource, the attributes of the players and the internal and external institutional context.	Other: *Cropping intensity as a proxy for water scarcity (inverse relationship), continuous captures wet and dry season.*	Distance to market; age of irrigation association; group size; origin of IA - irrigation association (self-organised/ government assistance); gender (% women in IA); farm size (proxy for wealth); governance structure of IA	Durable peace/ stable peace/ no significant conflict/ cooperation: *Collective action measured by two proxies: free riding in the payment of irrigation feed; free riding in terms of labour contribution towards maintenance of irrigation system.*
Bardhan (2000)	Interprovincial	Communities: *Water users'*	Asia: *6 districts in Tamil Nadu*	Common property management.	Other: *Number of months there*	Multiple socio-economic indicators.	Other: *Water allocation rules frequently*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
		organisations			*is access to irrigation; whether irrigation channel is lined; whether topographical nature of the area precludes equal access to water for all the farmers.*		*violated by at least one group; no conflict over water within village in the past 5 year; index of quality of maintenance of distributaries and field channels.*
Bernauer et al (2010)	Aggregate national level	• State • Civil society	• Global • Africa	Rainfall and temperature indirectly lead to conflict through changes in economic growth. Uses rainfall/ temperature as IV, by first examining relationship between rainfall and	Meteorological variable: *Precipitation using various measures: Standardized Precipitation Index (SPI 6); yearly moving average of precipitation (difference*	Yearly moving average of temperature (CRUTEM3); political institutions (Polity IV). Control variables: GDP per capita (Penn World Tables); population;	• Crisis/ violent conflict: *25 battle-related deaths (Uppsala / PRIO)* • Other: *Economic growth (first equation) (Penn World Tables).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				economic growth in an econometric model.	*between the current year's precipitation level and the average of the previous 30 years) (GPCC, CRU).*	population growth; ethnolinguistic fractionalisation (Fearon & Laitin, 2003); mountainous terrain (Fearon & Laitin, 2003); oil exporting countries (Fearon & Laitin, 2003); regional dummy variable.	
Bogale & Korf (2007)	Intracommunity: *Intra-group dynamics among agro-pastoralists*	Households	Africa: *Somali region, Ethiopia*	Agropastoralist households will accommodate pastoralists on their common grazing land only if the private benefits from accommodating the pastoralists exceed the cost they are	Threshold indicator: *Drought years*	Socioeconomic household characteristics.	Durable peace/ stable peace/ no significant conflict/ cooperation: *Reciprocal arrangements, sharing calves, using milk as proxies for*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				supposed to incur (the net benefit is positive).			*collaboration.*
Brochmann & Gleditsch (2006a)	International: n=2 *Unit of analysis is the dyad-year (year when a treaty is signed)*	State	Global	No model, almost absent logical framework. Lack of proper and clearly stated hypothesis.	Threshold indicator: *Drought: when one or both states have experienced a drought at any time during the past five years (EM-DAT).*	Peace history (number of years since the last MID in the dyad since the younger of the two countries gained independence), regime type (Polity IV); proximity (distance between capitals and contiguity, ICoW), major power (ICoW) economic strength (GDP) % of basin in the upstream state; alliances (dyad	Other: *Treaty existence and treaty signing from Transboundary Freshwater Dispute Database.* *Water events variable from International Water Events Database (water event registered in the dyad the previous year).* *Two dichotomous variables from the 15 point*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
						pair part of entente or defence pact, ICoW); joint memberships of IGOs (ICoW); regional differences (SSA and MENA).	*Basins at Risk scale (Yoffe et al 2003). Cooperative event (1-7) and Conflictive event (-1 -7).*
Brochmann & Gleditsch (2006b)	International: n=2	State	Global	Cornucopian framework. Shared rivers are likely to promote cooperation as well as conflict.	Threshold indicator: *Drought: whether one or both countries have experience a drought at any time during the past five years (EM-DAT)*	Shared basin (Transboundary River Basin Registry) Critical regions (SSA and MENA)	Durable peace/ stable peace/ no significant conflict/ cooperation: *Dyadic trade (US$, 1996); Joint memberships in international organisations are used as indicators of cooperation (ICoW,*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							Pevehouse et al, 2004).
Brochmann & Hensel (2008)	International: n=2	State	• Central America • European Union: *Western Europe* • Middle East • North America • South America	Upstream/downstream claims most likely to occur when water is scarce, the river is long (proxy for importance of river e.g. agriculture, energy, navigation), river crosses international boundary rather than acts as a border but likely to experience peaceful settlements. River claims are less likely to begin when river treaties already exist. Using liberal institutionalism theory, argue that dyads with democratic regimes	Physical water stress index: *Water supply: Water discharge and water runoff; Water supply: water demand (population density of river basin) (TFDD)*	Length of river (ICoW), river claim salience (ICoW), existence of river treaties (TFDD), shared IGO membership (Pevhouse et al, 2004), trade interdependence between dyads (ICoW), Polity IV (Marshall et al, 2008).	• Durable peace/ stable peace/ no significant conflict/ cooperation: *Peaceful negotiations (ICoW)* • Other: *River claim between dyads (ICoW)*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				are more likely to cooperate.			
Buhaug & Theisen (2010)	Aggregate national level	• State • Civil society	Africa	Eco-violence conceptual framework	Meteorological variable *Interannual and long-term preciptation deviations (GPCP).* Threshold indicator *Intra-annual rainfall variability (0.5 x 0.5 Standardized Precipitation Index), coded drought as three consecutive months with at least 1 SD below normal,*	Ethnopolitical exclusion (EPR database); democratic institutions (Polity IV); IMR; population size; decay function for time since last conflict (UCDP/PRIO).	Crisis/ violent conflict *Onset of civil war - 25 battle deaths/ year (UCDP/PRIO)*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
					or two consecutive months with at least 1.5 SD below normal. Two dummy variables for drought reported in one grid cell, and a second for drought reported in more than one cell during that year.		
Buhaug (2009)	• Interprovincial • International: n=2	State	Africa: *SSA*	Based on eco-scarcity framework, but no model or hypothesis.	Meteorological variable *Preciptation (Global Precipitation Climatology Centre).*	Temperature	Crisis/ violent conflict *Civil conflict (>25 deaths) Uppsala Conflict Data Program/PRIO*
Burke *et*	Aggregate	• State	Africa:	*Variability in*	Meteorologica	Country level	Crisis/ violent

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
al (2009)	national level	• Civil society	*SSA*	*temperature and precipitation in highly dependent rain-fed areas leads to conflict due to reductions in agriculture performance.*	l variable: *Country level variations in precipitation (CRU).*	variations in temperature (CRU), per capita income, democracy (Polity IV).	conflict: *Civil war - 1000 battle related deaths (Uppsala/PRIO)*
Burke *et al* (2010)	Aggregate national level	• State • Civil society	Africa: *SSA*	*Eco-security conceptual framework.*	Meteorological variable: *Deviation in precipitation (CRU)*	Deviations in temperature (CRU)	Crisis/ violent conflict: *Civil war - 1000 and 25 battle deaths/year analysed separately (Uppsala/PRIO conflict data)*
Dayton-Johnson (2000)	Intracommunity	Households: *members of water users association*	Central America: *Mexico, Guanajuato*	Quality of infrastructure maintenance (cooperation) is related to various 'distributive rules' (water availability)	Other: *Irrigation supply (1000sm3): water available in the reservoir*	Group size, economic inequality (Gini coefficient of landholding), social heterogeneity	Durable peace/ stable peace/ no significant conflict/ cooperation: *Collective maintenance is a*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				more than structural characteristics (such as group size, inequality).	*at the beginning of the irrigation season*	(number of different villages from which the users are drawn), local wages (proxy unit for cooperation due to opportunity cost), government constructed system.	*proxy for cooperation and includes three variable: maintenance of canal slopes; condition of field intakes; filtration.*
De Stefano *et al* (2010)	• Interprovincial • International: n=2, n>2	State	Global	n/a	Other: *Water quantity, water quantity and other events listed in the International Water Events Database.*		Other: *Water event intensity scale (modified from Yoffe et al., 2003)*
Dinar (2009)	International: n=2	State	Global	Cooperation is most likely to take place when the resource is neither abundant	Water stress index with social parameters:		Other: *Water treaties (treaty/no treaty)*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				(when there is no real impetus for cooperation) nor highly scarce (when there is little of the resource to divide among the parties or the degradation too costly to manage). Rather, formal coordination in the form of an international water treaty is most likely to ensue at levels of moderate (or relative) scarcity	*Water Poverty Index (WPI) (Lawrence, Meigh, and Sullivan 2002)*		
Dinar *et al* (2010)	International: n=2	State	Global	Predicts a curvilinear relationship between treaties and scarcity. When water is not scarce, riparian states are in less	Meteorologica l variable: *Water variability measured using: runoff data (Global*	Democracy and governance (Neumayer, 2002); trade (DOTS and COMTRADE); diplomatic	Durable peace/ stable peace/ no significant conflict/ cooperation: *Treaty data (226 country dyad*

Study	**Spatial Scale**	**Population focus**	**Country/ countries studied**	**Conceptual framework/ pathway**	**Independent variable measure (freshwater)**	**Other independent variables**	**Dependent variable measured**
				need to cooperate as there is sufficient supply. As scarcity levels increase, the impetus for cooperation increases. But as water becomes extremely scarce, there is little to cooperate over and formalised treaty formation is less likely. Democracy, governance, country relations, trade interdependence, power asymmetries, cross-boundary rivers are also confounding factors.	*Runoff Data Centre); precipitation data (Climate Research Unit from CGIAR)*	relations (ICOW); GDP and GDP per capita (proxy for power asymmetries); river geography (e.g. cross-boundary); existing treaties (TFDD).	*observations)*
Dinar *et al* (2007)	International: n=2	State	Global	Resource scarcity, while a source of conflict, is also a	Physical water stress index: *Water*	Governance (Corruption Perception Index,	Durable peace/ stable peace/ no significant

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				driver for cooperation between states - neoliberal theoretical framework. And, specifically predicts an inverted U relationship between cooperation and scarcity.	*availability per capita (Population Action International)*	Transparency International, 2004); trade interdependence (DOTS, COMTRADE), geography of river (e.g. cross border);	conflict/ cooperation: *Cooperation between two riparian states measured as existence of a treaty.*
Fayankinnu (2005)	Intracommunity	Individuals	Africa: *Nigeria*	Demand-induced scarcity leads to social conflicts.	• Meteorological variable: *Dry season.* • Other: *Number of boreholes.*		Other: *Social conflict defined as physical violence, the use of charms, verbal assault, breaking of water containers.*
Funder *et al* (2010)	Intracommunity	Communities	Africa: *Namwala district, Zambia*	Water-related conflict and cooperation takes place in response to	Meteorological variable *Wet and dry seasons*		Other: *Inventory of all formally reported public water*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				situations of actual or potential competition (situations in which two or more parties seek access to the same water resources). At times, such conflict or cooperation is latent, while at other times it is expressed as "water events".			*events, defined as "actions (or set of actions) that seek to secure one or more parties' access to water by: challenging other parties' access; confirming own or other parties' access; collaborating with other parties to secure access." Conflictive: one or more parties challenge other parties access to a particular water resource; Cooperative: one or more parties engage in jointly*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							coordinated actions with other actors to secure shared water access or acknowledge other parties access to water.
Furlong (2006)	International: n=2	State	Global	neo-Malthusian framework.	Physical water stress index: *Freshwater availability (Hauge and Ellingsen, 1998). Country with less than 10,000 m3 per capita per year is coded as water-scarce.*	Shared rivers (Toset, 1998), alliances (ICoW), regime type (Polity III), major power status (ICoW), peace history, energy consumption (proxy for economic development), boundary length.	Crisis/ violent conflict: *MID with minimum one fatality (ICoW).*
Gizelis &	• Interprovincial	State	Global	Intrastate water resource conflict is	• Meteorological	Governance proxy	Crisis/ violent conflict

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
Wooden (2011)	• Aggregate national level			institutionally driven.	variable: *Controls: precipitation on every 5 years (FAO); water dependency ration (FAO).* • Physical water stress index: *Internally renewable freshwater resources per capita (IRFWR, FAO Aquastat, 2001) at intervals of*	(institutionalised democracy, Policy IV); Index of democracy (Vanhanen, 2000); urbanisation (World Bank); crop production index (FAO); rural population density (World Bank); GDP per capita (World Bank). Control for total population and occurrence of conflict during the study period, number of consecutive peace years since the study period.	*25 battle-related deaths/ year (UCDP 2008).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
					5 years.		
Gleditsch (2006)	International: n=2	State	Global	Dyads with rivers running across the boundary would be expected to give rise to resource scarcity-related conflict, while in dyads where the river forms the boundary conflict may arise becaue river boundaries are fluid and fuzzy.	• Meteorological variable: *Average rainfall.* • Threshold indicator: *Drought in last 5 years.* • Other	Shared basin; river boundary; cross boundary river; basin size; upstream basin; percent upstream.; regime type (Polity IV); level of development (per capita energy consumption); population size of dyad; major power; alliance; distance; boundary length.	Crisis/ violent conflict: *MID (ICoW), minimum one fatality.*
Raju *et al* (2005)	International: n=2 n>2	State	Global	As a coping strategy with uncertainty and economic disruption (but not conflict) created by droughts, states are more	Physical water stress index: *PDSI: current year; past year; three-year moving*	Trade; development (natural log of GDP per capita in $US); military capabilities	Durable peace/ stable peace/ no significant conflict/ cooperation: *Treaty formation,*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				likely to enter into water treaties during times of water stress.	*average; shared drought (PDSI of -1 to -4).*	(ICoW); dyad democracy (Polity IV).	*specifically addressing water as a resource (TFDD). Disaggregate between treaties relating to hydropower/navigation; treaties that address freshwater quality/quantity; treaties that specifically allocate freshwater.*
Hamner (2009)	Aggregate national level: *Civil war and domestic armed violence*	State: *nation state*	Global	Eco-violence framework (Homer-Dixon)	Physical water stress index: *Freshwater availability per capita (dummy variable: 0-500m3 per*	Supply induced scarcity: in addition to freshwater: deforestation (FAO Production Yearbook) and land degradation	Crisis/ violent conflict: *For Logit model analysis - Civil war (Correlates of War dataset, 1000 battle deaths in a single*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
					capita per year (WRI)	(World Map of the Status of Human Induced Soil Degradation). Demand induced scarcity: % change in density during period 1980-1992 (from Demographic Yearbook). Structural scarcity: income inequality (from World Bank Economic Review). Other conflict generating factors: level of economic development (GNP); type of	*year, 1982-1992) and Domestic armed conflict (Wallensteen and Sollenberg (1997) - 25 annual battle deaths).* *Cross-sectional analysis - continuous dependent variable of number of battle deaths as percentage of the total population (only civil war, not minor armed conflicts).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
						political regime (Polity III); political stability (regime in place for >10 years = stable).	
Hauge (1998)	Aggregate national level	Civil society	Africa: *SSA*	Long-term: Following Collier and Hoeffler (2002, 2004). Land degradation, climatic and freshwater scarcity negatively impact on land productivity associated with lower returns to agriculture , the opportunity cost to violence decreases, leading to the higher likelihood of conflict. However, tropical zones	• Meteorological variable: *% change in annual rainfall from previous year; dummy variable for SD > 1/2 from mean (30 year normal) (GPCP)* • Physical	Static land degradation (FAO); climate suitability for Eurasian climate (Köppen-Geiger classification) Control variables: per capita GDP, oil producer, % mountainous terrain (Fearon and Laitin, 2003), and GDP growth.	War: *Civil war (PRIO/Uppsala)*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				receive high levels of rainfall but are characterise by poor soil quality. Therefore, the relationship between freshwater and conflict may also be positive. Short-term (interannual variability): Higher levels of rainfall relative to previous years may be associated with higher returns of agriculture and lower risk of conflict.	water stress index: *Per capita renewable water resources (FAO).*		
Hendrix & Glaser	Aggregate national level	• Communities • Local/	Africa: Africa-wide. Every country in	Doesn't provide formal model, but discusses five	• Meteorological variable:		Crisis/ violent conflict: *Civil conflict*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
(2007)		regional government • State • Private sector • Civil society • Military	Africa, including North Africa is coded.	plausible mechanisms (not mutually exclusive). 1) Intersectoral: Conflict among consumers of water, including those who depend on water as an input for their products; 2) Price disputes between rural producers and urban consumers (e.g. food riots); 3) Internal migration: internal displacement of populations lead to competition over	*Hydro-meteorological disasters: annual standardised rainfall deviation from the long-term (1979-2008) panel mean of rainfall (Global Precipitation Climatology Project).*		*onset (25+ annual battle deaths), low level violence and non-violent events e.g. riots, demonstrations (Social Conflict in Africa Database, SCAD).*[2]

[2] SCAD contains information on instances of: 'contentious collective action such as protests, riots and strikes; but includes also intra-governmental violence, such as coups or factional fighting within the military; violent repression by the government or its agents; anti-government violence that does not meet the conventional thresholds for civil conflict; and extra-governmental violence, or violence by non-state, organised militant group against individuals, rival communal groups, or other social actors not involving the state.

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				jobs, housing, other resources (inter-communal conflict); 4) Reduced state capacity: negative macroeconomic impacts reduce state capacity and lead to political instability; 5) Long-term macroeconomic impacts: negative development effects of hydro-meteorological disasters can increase risk of conflict.	• Threshold indicator: *Drought and flood events using CRED EM-DAT dataset.*[1]		
Hendrix (2010)	International: n=2	State	• European Union: *Western Europe*	Test both neo-Malthusian and neo-liberal theories. Increased water	Physical water stress index: *Basin-level data on water*	Presence of river treaties over the basin (TFDD); river crosses	• Crisis/ violent conflict: *Militarisation of river*

[1] Events meet the CRED definition of disaster if one or more of the following criteria are met: 1) 10 or more people were reported killed; 2) 100 people were reported affected; 3) declaration of a state emergency; and/or 4) it led to calls for international assistance see http://www.emdat.be/criteria-and-definition).

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
			• Middle East • North America • South America	scarcity and water demands makes states more likely to incite river claims and militarised conflict over these claims, but treaties can help prevent emergence and militarization of river claims.	*supply (water discharge and runoff) and water demands (average population density)(TFD D)*	border between riparian state and use state capabilities measure (ICoW Composite Index of National Capabilities) to disern the more powerful state, regime type (Polity IV); salience (ICow).	*claims (ICoW, MID dataset).* • Other: *Outbreak of river claim between dyad (ICoW). Defined as an explicit contention between official government representatives of two or more nation states regarding the use or abuse of international river waters.*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							Type of claim is distinguished (quality, quantity or navigational).
Hensel & Brochmann (2007)	International: n=2	State	Global	High levels of water scarcity increase the frequency of explicit claims over water, increase chances of militarized conflict, and make it more difficult for conflict management institutions to be effectively created.	Physical water stress index: *renewable water resources per capita; annual water use per capita; annual water use as a % of renewable water.*	River specific institutions, general conflict management institutions. Control for: joint democracy (Polity IV); river claims salience (ICoW); power asymmetry (Material Capabilities, ICoW); history of recent conflict.	• Durable peace/ stable peace/ no significant conflict/ cooperation: *Bilateral and third party effort to manage conflict.* • Crisis/ violent conflict: *MID over given river claim*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							• Other: *Effectiveness of peaceful conflict management.*
Hensel *et al* (2006)	Aggregate national level	• State • Civil society	Africa: *Sudan, Darfur; Sahelian/ West Africa*	None provided	Meteorological variable: *Rainfall (CRU, & GPCP)*		Crisis/ violent conflict: *years of war (PRIO0; civil conflict in 1980s and 1990s (PRIO); years of war (Collier)*
Kevane & Leslie (2008)	Interprovincial	• State • Civil society	• Africa • Asia • Central America • Eastern Europe • Middle East	Variant of neo-Malthusian arguments of scarcity leading to conflict due to weak institutional capacity, deprivation and grievance.	Meteorological variable: *Rainfall deviations from normal (using Weighten Anomaly Standardized Precipitation Index* -	Control for relative IMR and trade openness compared to global mean; democratic institutions (Polity) and population.	Crisis/ violent conflict: *Low and high-level civil conflict (PRIO/Uppsala Conflict Database).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
			• South America		*WASP), lagged by 1 year.* *Mean annual locally-derived runoff (using a Water Balance and Transport Model)*		
Levy *et al* (2005)	Intracommunity	Communities: *Members of 'borehole syndicates'.*	Africa: *Botswana*	Common Property Management. Specifically: water shortages during the dry season has a positive impact on collective actions (since reliance on borehole during this period raises the stakes for members to act collectively to ensure that water is available on a	• Water stress index with social parameters: *Water shortage during the dry season.* • Other: *Source of water*	Number of households who are members of syndicates; heterogeneity in cattle ownership; average herd size per member; total distance to major market where cattle are sold; membership in other village organisations; age	Durable peace/ stable peace/ no significant conflict/ cooperation: *Index of collective action including 5 variables: disputes; number of meetings; percentage of attendance; non-payment of fees;*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				permanent basis).	*during the wet season.*	of syndicate; years of schooling of the chairman; presence of hirers; percentage of women members; turnover ratio of membership.	*and punishment.*
Makepe (2005)	Intercommunity		Africa: *Uganda, Ethiopia, Kenya*	Eco-violence theoretical framework (Homer-Dixon; Baechler)	Meteorological variable: *Spatially disaggregated monthly precipitation (NOAA)*	Vegetation (NOAA, AVHRR), forage (LEWS), peace indicator scores from CEWARN (alliances, exchanges, mitigation, initiatives), conflict indicator scores (aggravators, pressure,	Crisis/ violent conflict: *Pastoral conflict (human deaths, livestock losses, organised raids), from CEWARN.*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
						provocation).	
Meier *et al* (2007)	• Interprovincial • International: n=2	State	Global	Eco-violence theoretical framework (Homer-Dixon,Baechler)	• Physical water stress index: *Easily available freshwater (TERRASTAT)* • Other	Soil degradation (ISRIC); population growth and density (CIESIN); regime type (Polity IV); political change (Polity IV); annual GDP (proxy for state capacity; state adaptability).	Crisis/ violent conflict: *Civil conflicts (Uppsala/PRIO data).*
Raleigh & Urdal (2007)			Global	States experiencing environmental scarcity are more likely to be involved in international conflict.	Physical water stress index: *Per capita freshwater availability (WRI)*	Fish stocks (WRI), Soil degradation (GLASOD); population density (Demographic Yearbook); environmental scarcity	War: *Militarised International Dispute (ICoW)*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
						(aggregate environmental scarcity score); vulnerability: PCA generated factor of inequality, number of subsistence farmers, land burden, fuel wood as a percent of energy consumption; and proxy measures land burden and number of subsistence farmers (all from State Failure Task Force). Control for: regime type	

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
						(Polity III), economic development (per capita real GDP), economic interdependence (trade as a % of GDP), military capability, geographic opportunity (number of borders), peace history.	
Stalley (2003)	International: n=2; n>2	State	Global	Neoliberal theoretical framework. Institutionalisation of river treaties depend on the urgency (degree of scarcity) to cooperate and contextual political	Physical water stress index: *Per capita renewable water (FAO Aquastat)*	Per capita GDP; trade interdependence (ratio of trade between all agreement members to the total trade members engage with the world);	Other: *Additive index of institutional features contained in each agreement: monitoring, enforcement, conflict resolution,*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				factors. High levels of institutionalisation will be difficult to achieve in the absence of factors that make it desirable.		regime type (Polity IV). Control variables: military alliances, history of MID in previous five years, power concentration (ICoW Material Capabilities composite index).	*international organisation from IFTD*
Stinnett (2009)	Aggregate national level	• State • Civil society	Global	Environmental scarcity limits capacity to cope with environmental stressors and increases the risk of civil war and armed conflicts.	• Physical water stress index: *Water per capita* • Threshold indicator: *Drought*	Land degradation (GLASOD); ongoing conflict in country.	Crisis/ violent conflict: *> 25 battle-deaths per year, only if new onset is preceded by two or more years of peace.*
Theisen (2008)	• Interprovincial: *Including*	• State • Civil society	Africa	Eco-violence theoretical framework. Drought	Threshold indicator: *Drought:*	Political marginalisation of ethnic groups	Crisis/ violent conflict: *At least 25 battle-*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
	civil war (intra-state war) • International: n=2			increases the local risk of civil war; and the effect of drought on civil war risk is higher in politically marginalized areas.	*proportional change in rainfall from the previous years, % deviation from annual average (GPCC), binary drought indicator from UNEP, Standard Precipitation Index measuring negative deviations from normal rainfall during the previous 6 months (EM-DAT, CRED).*	(Geo-Referencing of Ethnic Groups, Ethnic Power Relations) with a one-year lag to control for reverse causality. Control for population; distance to nearest international border, dummy variable for cells that contain a capital city; democracy (Polity IV); IMR; conflict history.	*deaths /year (UCDP/PRIO)*
Theisen	Intercommun	• Commun	Africa:	*DES framework*	Meteorologica	Population	Crisis/ violent

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
(2010a)	ity: *Inter-group*	ities • State: *state, or state actors*	*Kenya*	*(Kahl, 2006). Densely populated areas run a higher risk of inter-ethnic violence. Election years are more prone to conflict than non-election years.*	l variable: *Spatial rainfall shortage using (GPCC): 1) percentage change in precipitation from t-1 to t; 2) deviation from mean rainfall in the cell.*	density (CIESIN Gridded Population of the World dataset), temperature (CRU TS 3.0), ethnicity (GREG), election year, non-monetary measure of poverty (1999 Population and Housing Census), dummy variable to capture whether the cell has one or more district national boundary or not.	conflict: *Spatial data of non-state and one-sided violence that generated at least 25 deaths for a year. Dataset generated from reporting in Kenyan daily newspaper.*
Theisen (2010b)	Intercommunity: *Inter-group conflict*	Civil society	Africa: *SSA*	Neo-Malthusian: Eco-violence theoretical framework (Homer-	Meteorological variable *5-year average precipitation,*	Population density and population change (CIESIN);	Crisis/ violent conflict: *Non-state conflict: "the use*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
				Dixon/ Baechler)	*% change in precipitation for 2001-2005; standard deviation of precipitation within 2001-20005 (CPC, 2006).*	infant mortality (CIESIN); state capacity (distance to national capital from centre of each grid). Controls: for spill-over effects; size of country in km2; democracy (Polity IV); time since last regime change.	*of armed force between two organised groups, neither of which is the government of a state, which results in at least 25 battle-related deaths" (Uppsala)*
Thiesen & Brandsegg (2007)	• Spatial Scale • Interprovincial • International: n=2 *examines treaties between 2 countries*	State	Global	Draws on realist, neoliberal neo-Malthusian theories.	Physical water stress index: *Per capita freshwater availability (Engelman 2002)*	Alliances; strength of militarised threat; power distribution (material capabilities, ICoW); regime type (Polity IV); economic interdependence.	Durable peace/ stable peace/ no significant: conflict/ cooperation *Water quality and quantity treaties (IFTD, Wolf 2007).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
Tir & Ackerman (2009)	International: n=2 *Dyads, boundary-crossing rivers from Correlates of Water contiguity dataset.*	State	Global	Examines a series of hypotheses based on shared river resources and conflict: countries that share a river have more conflict; the more shared rivers, the more conflict; two countries with water scarcity are more likely to have conflict.	Threshold indicator: *<10,000m3 per capita freshwater availability (surface and groundwater).*	Control for: regime type (Polity III); economic development (per capita energy consumption); major power; alliances (ICoW).	Crisis/ violent conflict: *MIDs (ICoW).*
Toset (2000)	Intercommunity	• Individuals • Households • Communities	Africa: *Kenya, Marsabit*	Eco-scarcity conceptual framework (Homer-Dixon, Baechler)	• Meteorological variable: *Annual rainfall* • Water stress index with social parameters		Crisis/ violent conflict: *Livestock raiding, armed attack, murder.*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
					: *Use and management of wells: ownership and access rights, allocation of water.* • Threshold indicator: *Drought during 2000*		
Witsenburg & Roba (2002)	International: n>2	State	Global	No model.	Other		• Durable peace/ stable peace/ no significant: conflict/ cooperation: *Signing of treaties.* • Crisis/ violent

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							conflict: *Disputes (International Crisis Behaviour dataset, ICB) over scarce water resources. Disputes which were considered to be international crises defined as (1) basic national values are threatened (e.g. territory, influence, or existence), (2) time for making*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
							decisions is limited, and (3) the probability for military hostilities is high.
Wolf (1998)	Intracommunity	Individuals	South America: *Bolivia, squatter settlement in Cochabamba.*	Common property management	Meteorological variable: *Dry season.*	Home ownership; social relationships.	Other: *Cooperative behaviour: percentage of respondents attending Neighbourhood Council meetings over five seasonal periods.*
Wutich (2009)	International: n=2 n>2	State	Global	None	• Meteorological variable: *Precipitation.* • Physical water	GDP, GDP/capita, population density, overall relations, relative power, rate of population	Other: *Water events (BAR scale).*

Study	Spatial Scale	Population focus	Country/ countries studied	Conceptual framework/ pathway	Independent variable measure (freshwater)	Other independent variables	Dependent variable measured
					stress index: *Volume of freshwater availability per capita (WSI).* • Water stress index with social parameters: *Social Water Stress Index (WSI weighted by adaptive capacity HDI).*	growth, no. of dams, dam density, basin area, no. basin countries, HDI, agriculture as a % of GDP, % labour force, hydropower.	
Yoffe (2003)					•		

D.3 Quality assessment of studies by scale of analysis

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
Araral (2009)	Intracommunity	Individuals: *Farmers within irrigation associations*	Asia: *Philippines*	Collective action is associated with water scarcity, proximity to markets, group size, wealth and governance structures. Specifically, monetary free riding (lack of collective action) is associated with cropping intensity (water scarcity). Water scarcity has a curvilinear effect on monetary free riding - collective action is more difficult when water is either abundant or extremely scarce. IAs controlled by farmers are associated with lower levels of free-riding and mediates the effects of other variables (e.g. water scarcity and age of IA).	Medium
Bardhan (2000)	Intracommunity	Communities: *Water users' organisations*	Asia: *6 districts in Tamil Nadu*	Number of months in a year when there is access to water is positively and significantly related to the quality of the maintenance of distributaries and field channels. When there is more access to irrigation (for more time during the year) the return to investing effort in maintenance of field channels is higher and people are more likely to behave cooperatively and help maintain the channels.	Low
Bernauer et al (2010)	Aggregate national level	• State • Civil society	• Global • Africa	While there are some negative impacts of climate variables on the likelihood of conflict, the effect is not significant. Non-democratic nations are more likely to experience armed	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				conflict when economic conditions deteriorate.	
Bogale & Korf (2007)	Intracommunity: *Intra-group dynamics among agro-pastoralists*	Households	Africa: *Somali region, Ethiopia*	Resource sharing offers asset-poor households opportunities to stabilise and enhance their asset-base in drought years, providing incentives for cooperative rather than conflicting relations with intruding pastoralists. This is particularly true for asset-poor households in the receiving community.	Low
Brochmann & Gleditsch (2006a)	International: n=2 *Unit of analysis is the dyad-year (year when a treaty is signed)*	State	Global	Drought has a positive impact on dependent variable. Dyads where one or both countries have been affected by drought are more likely to have a treaty. Higher probability of treaty existing if dyad has a history of peaceful relations and other kinds of cooperation measured (alliances [not significant] and memberships in IGOs). Probability of treaty existing in dyad increases with economic strength. Larger the % of basin in an upstream state, the greater the chances of a treaty being present. Neighbouring countries have more treaties. Conflictive as well as cooperative events tend to stimulate treaties, and treaties in turn contribute to water cooperation. Treaties also result from conflictive events. Treaties do not seem to inhibit future water conflictive events. A treaty signed two years prior to present may catalyse a conflictive event (although caution because of	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				selection effect).	
Brochmann & Gleditsch (2006b)	International: n=2	State	Global	Dyads that share a basin where at least one of the countries have experienced drought during the past five years seem to trade more, but join less IGOs than other dyads. Sharing of a river is positively related to two general measures of interstate cooperation, trade and joint memberships of international organisations. These results are not strong. Conclude: scarcity, region and regime type matters. Additional factors not included may also be important (e.g. salience). Neo-Malthusian and cornucopian conceptual frameworks could both be correct. The two are not mutually exclusive.	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				Previous conflict can contribute to later cooperation and vice versa. Conflict and cooperation can even come about at the same time.	
Brochmann & Hensel (2008)	International: n=2	State	• Central America • European Union: *Western Europe* • Middle East • North America • South America	The availability of water is the most important factor when considering river interaction. Scarcity, higher demands on water, longer rivers, and cross-border rivers all increase the likelihood that riparian states will come into diplomatic conflict over a shared river. Scarcity and longer rivers increase the likelihood that states involved in such disagreements will negotiate to try to manage or settle the issues. Concludes: little evidence to support the water wars hypothesis and supports theory that states will seek to cooperate when an issue is considered vital. Relationship between democracy implies that negotiations may be hampered by lack of trust and insufficient information sharing.	Medium
Buhaug & Theisen (2010)	Aggregate national level	• State • Civil society	Africa	None of the precipitation variables have a significant impact on conflict. But, weak evidence that drought two years before increased the risk of conflict. Population size has the	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				most significant impact on conflict risk. Ethnopolitical exclusion is positively correlated to conflict risk. IMR and democracy are also positively correlated to the risk of civil war onset, but are not significant.	
Buhaug (2009)	International: n=2	State	Africa: *SSA*	No robust correlation between climate variability and civil war. The only model that produces a significant relationship is one that shows that major civil wars (years with at least 1,000 battle deaths) are more frequent in years following unusually wet periods, thus contradicting the scarcity-conflict hypothesis.	Medium
Burke *et al* (2009)	Aggregate national level	• State • Civil society	Africa: *SSA*	Temperature change is significantly related to the likelihood of civil war. There is a weak relationship between precipitation and conflict. Argues temperature may be a better predictor of civil war.	Medium
Burke *et al* (2010)	Aggregate national level	• State • Civil society	Africa: *SSA*	Robust relationship between climate change (both temperature and precipitation) and civil war, though this relationship has weakened recently (possibly due to economic and political changes), and the relationship is stronger for temperature than precipitation.	Medium
Dayton-Johnson	Intracommunity	Households: *members of water*	Central America:	Irrigation has a negative (though non-significant) effect on side-slope maintenance (one measure of cooperation).	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
(2000)		*users association*	*Mexico, Guanajuato*	Social heterogeneity and landholding inequality, however are significantly associated with lower maintenance in all measures of cooperation.	
De Stefano *et al* (2010)	International: n=2, n>2	State	Global	International cooperation over transboundary river basins are more prevalent than conflict. However, dataset limited to English-language and therefore biased, particularly in relation to South America. Comparison between 1948-1999 and 2000-2008 suggests recent move towards less cooperative interactions between some countries, but this is not detected in the MENA region. Jordan, Tigris-Euphrates/Shatt al Arab, Danube and Ganges-Brahmamaputra-Meghna have reported an increase in positive events. Mekong has also reported an increase in event, but these have been cooperative. North America has experienced an increase in mild conflicts (legal) relating to water rights or treaties. However, infrastructure and water quality are consistently the most conflictive. Flood control, joint management and technical aspects, however have become increasingly cooperative. There has been an increase in groundwater disputes	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				Almost all negative events reported between 2000-2008 were mild verbal expressions of discord through diplomatic-economic hostile actions. Nor was there any evidence of the extremes of the BAR scale.	
Dinar (2009)	International: n=2	State	Global	Relationship between water scarcity and cooperation is an inverted U-shaped curve. At low levels of scarcity, cooperation (measured by international water agreements) is less likely. As scarcity rises, cooperation begins, but cooperation decreases again as the resource becomes scarce.	Low
Dinar *et al* (2010)	International: n=2	State	Global	Basin precipitation runoff variability explains the variance in the level of treaty cooperation across the analyzed basins: confirming the suggestions of an inverted U-shape of relationship between water variability and treaty cooperation. Diplomatic, trade relations support cooperation, while uneven economic power inhibits cooperation.	Medium
Dinar *et al* (2007)	International: n=2	State	Global	Scarcity and cooperation have an inverted U curve relationship. Trade and governance are both significant in explaining cooperation.	Medium
Fayankinnu (2005)	Intracommunity	Individuals	Africa: *Nigeria*	Water scarcity generates social conflict between "indigenes" and students in Akungba-Akoko	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
Funder *et al* (2010)	Intracommunity	Communities	Africa: *Namwala district, Zambia*	Local water competition situations often involve both conflictive and cooperative events often in a dynamic succession to one another (conflict leads to cooperation and vice versa). The majority of water events are conflictive and often take place at the intracommunity level between different types of water users rather than the same users (viz. pastoralists vs. crop-orientated livelihoods; gender; state-hydropower vs. pastoralists). Most conflictive events were low level oral disagreements or voicing protest Of the 183 recorded events, only one involved rioting and physical violence. Third party involvement tends to be primary local institutions such as Headmen.	Low
Furlong (2006)	International: n=2	State	Global	Significant relationship between conflict and one or more shared rivers, and between water scarcity and conflict. No significant (weakly positive) relationship between boundary length and the risk of conflict. The presence of one or two major powers and peace history are negative correlated with conflict. No significance found for economic development or regime type.	Medium
Gizelis & Wooden (2011)	Aggregate national level	State	Global	Level of water scarcity does not have a significant impact on the probability of conflict. But institutions appear to influence the capacity of states to adapt to their freshwater	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				needs by mitigating potential conflicts of interest that could escalate to intrastate wars. Water scarcity may also affect the nature and effectiveness of domestic institutions.	
Gleditsch (2006)	International: n=2	State	Global	There is no clear relationship between scarcity and MID. However, a shared basin (cross-boundary) is positively and significantly related to conflict; a river boundary is not (forms part of the state boundary). Most significant results are found the river salience. Argue that this may be due to the multiple benefits of river systems - good communications, hydropower, abundant fish and irrigation.	Medium
Raju *et al* (2005)	International: n=2 n>2	State	Global	States are less likely to enter into water treaties (navigation/hydropower) during times of water stress. States more likely to enter into water treaty (water quality, quantity) or water sharing treaty when drought occurs/ remains below PDSI of -1. Bilateral treaties are more likely to come into being during drought shared by both signatory states. Concludes: water-specific cooperation more likely under conditions of water scarcity. Contradicts realist and Malthusian arguments.	Medium
Hamner (2009)	Aggregate national level	State	Global	Low freshwater availability per capita, soil degradation, population density and deforestation are positively	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				associated with incidence of civil war/armed conflict. Some evidence that environmental degradation is more important for the risk of armed conflicts rather than civil war. Countries suffering from environmental degradation are more prone to civil conflict. But, economic factors are more important in predicting domestic armed conflict than environmental factors.	
Hauge (1998)	Aggregate national level	Civil society	Africa: *SSA*	Interannual variability of rainfall more significant determinant of conflict than climate, land degradation and water scarcity. Land degradation and climatic zone has no effect, long-term water scarcity decreases risk.	Medium
Hendrix & Glaser (2007)	Aggregate national level	• Communities • Local/ regional government • State • Private sector • Civil society • Military	Africa: Africa-wide. Every country in Africa, including North Africa is coded.	More deviation from average rainfall, the greater the probability of violent events. But low rainfall increases probability of non-violent and government targeted events, while high rainfall leads to violent and non-government targeted events. Extremes (positive and negative) in rainfall have large effects on all types of political conflict. The relationship is strongest for violent conflict, which is more responsive to abundant than scarce rainfall. Argue this may be due to tactical considerations of rebel groups. Insurgents may be less likely to launch violent campaigns when there are severe water shortages.	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				Supportive of hypothesis that discrete hydro-meteorological disasters are associated robustly with civil conflict or social conflict.	
Hendrix (2010)	International: n=2	State	• European Union: *Western Europe* • Middle East • North America • South America	Greater levels of water scarcity and greater demands on water increase risk of both claim onset and militarisation. Navigation claims, especially prone to lead to militarised conflict. River treaties significantly reduce militarisation. But, water allocation treaties significantly increase the risk of river claims over water quantity. Whereas water quality and navigation treaties 'almost perfectly' prevent the onset of river claims over their general subject matter. Claim militarisation is more likely over cross-border rivers and over claims that are more salient to the riparian states. Every militarised dispute over rivers in authors dataset involved a cross-border river. Democracies are better able to avoid river claims, but the effect was not significant for claim militarisation. Stronger upstream state is positively associated with increased risk of a claim onset. Conclusion: water availability and demand are crucial for the outbreak and militarisation of claims and river treaties	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				have mixed effects.	
Hensel & Brochmann (2007)	International: n=2	State	Global	Greater water scarcity increases the likelihood of MID and peaceful third party settlement attempts. Argue MID more likely in water scarce regions where there is a high degree of salience, but less likely if contending states share membership in general or river-specific institutions. River-specific institutions reduce likelihood of MID and increase the effectiveness of peaceful settlement attempts.	Medium
Hensel *et al* (2006)	Aggregate national level	• State • Civil society	Africa: *Sudan, Darfur; Sahelian/ West Africa*	Rainfall in Darfur did not decline significantly in the years prior to the eruption of major conflict in 2003; rainfall exhibited a flat trend in the thirty years preceding the conflict (1972-2002). Preliminary analysis suggests little merit to the proposition that a structural break several decades earlier is a reasonable predictor of violence in Darfur.	Low
Kevane & Leslie (2008)	Aggregate national level	• State • Civil society	• Africa • Asia • Central America	When rainfall was significantly below normal, the likelihood of conflict outbreak was higher the subsequent year. Regions with low levels of baseline water availability or high levels of variability are more likely to have conflicts than other regions. Strong relationship between rainfall	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
			• Eastern Europe • Middle East • South America	deviations below normal and the likelihood of high-intensity conflict. No such correlation for low-intensity conflict.	
Levy *et al* (2005)	Intracommunity	Communities: *Members of 'borehole syndicates'*.	Africa: *Botswana*	Water shortage during dry season has a positive and significant effect on aspects of cooperative behaviour (greater activity in meetings and number of meetings).	Medium
Makepe (2005)	Intercommunity		Africa: *Uganda, Ethiopia, Kenya*	No statistical significance between deaths and livestock losses and the independent variables, but was found for organised raids. Vegetation is positively correlated to the incidence of organised raids. There is no statistically significant relationship between rainfall and conflict. Argue that rainfall may be a too indirect measure of water availability. Conclude: aggravating behaviour along with a reduction in	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				peace initiatives and reciprocal exchanges is associated with an escalation in pastoral conflict, especially when coupled with an increase in vegetation (cover and stronger livestock) for organised raids.	
Meier *et al* (2007)	nternational: n=2	State	Global	Population growth and density, associated with increased risk, effects of land degradation and water scarcity are weak, negligible or insignificant. The results indicate that the effects of political and economic factors far outweigh those between local level demographic/environmental factors and conflict.	High
Raleigh & Urdal (2007)			Global	Water is statistically insignificant - although does not use dyadic model. Regime type, not statistically significant. All state vulnerability to environmental scarcity indicators generate statistically insignificant result. Soil degradation one of more influential variables. Even when environmental factors controlled, population density significantly increases the likelihood of conflict. No support for fish stocks and MID. Concludes: States suffering from environmental conflict more likely to be involved in MID.	Medium
Stalley	International:	State	Global	Institutionalisation of river treaties is associated with water	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
(2003)	n=2; n>2			scarcity and trade interdependence and to a lesser extent flow pattern of shared rivers (upstream/downstream) and level of economic development.	
Stinnett (2009)	Aggregate national level	• State • Civil society	Global	Unable to replicate Hauge and Ellingsen (1998). Little evidence for water scarcity and drought-conflict connection, and relationship is close to insignificant. High level of soil degradation, have significant relationship with risk of conflict. Population density and growth have no effect. Level of development, population size, instability and dependence on oil exports significantly related to civil conflict. Level of democracy, ethno-linguistic fractionalisation not significant.	High
Theisen (2008)	Intercommunity	• State • Civil society	Africa	Find virtually no relationship between 15 operationalisations of drought and civil conflict onset as well as several interactions with socio-political variables. Slightly reduced risk of conflict in areas with drought. No correlation between acute water shortage and increased risk of conflict. Location of civil war in Africa is best explained by: political, socioeconomic, geographic factors (population	Medium

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				density, size of marginalized population), and breaks out disproportionately in politically marginalised areas. Conclusion: drought is unrelated to the short-term risk of civil war.	
Theisen (2010a)	Intercommunity	• Communities • State: *state, or state actors*	Africa: *Kenya*	In support of climatic influence on the risk of conflict incidence. Wetter years are less safe than drier ones. Some effect of higher temperatures increasing conflict risk. More densely populated areas run a higher risk of conflict - but this is restricted to election years when conflicts occur more frequently in central areas. Multiethnic areas and less developed areas are more at risk of conflict incidence.	Medium
Theisen (2010b)	Intercommunity: *Inter-group conflict*	Civil society	Africa: *SSA*	Higher levels in rainfall coincide with a higher risk of conflict onset. Marginalized regions also run a higher risk. No substantive evidence to suggest that that changes in levels rather than changes in pressure on renewable resources are more related to conflict. Regions worse off in material terms are not affected harder by scarcities than other regions. Tentatively conclude that the risk of non-state conflicts is somewhat heightened by decreasing access to renewable resources.	High

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
Thiesen & Brandsegg (2007)	International: n=2 *examines treaties between 2 countries*	State	Global	Water scarcity, power distributions, economic interdependence, democratic governance all increase the likelihood that states will sign river treaties. Upstream/downstream relationships are insignificant. However, conclude that results imply that developing nations may be more at risk from conflict.	Medium
Tir & Ackerman (2009)	International: n=2 *Dyads, boundary-crossing rivers from Correlates of Water contiguity dataset.*	State	Global	A joint rivers increase the probability of a militarised and armed conflict. Dyads with water scarcity are estimated to have roughly 4 times higher risk of conflict than dyads without. Water scarcity is positively related to conflict, particularly when a river is shared across rather than along a border - the upstream/downstream relationship appears to be the form of shared water most frequently associated with conflict. The results are not particularly significant, however.	Medium
Toset (2000)	Intercommunity	• Individuals • Households • Communities	Africa: *Kenya, Marsabit*	Do not find a relationship between conflicts and increasing scarcity of water. There is less violence in drought years than wet years. Although this may indicate a strategic or lagged response. People do not engage in violent conflict over access to water resources. During drought years, cooperation is more likely to the extent that when a drought	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				is expected, warring communities often reconcile in order to share water and pasture. Suggest that during wet years, when more conflicts are observed, may indicate opportunism (livestock are better fed, raiding is easier due to vegetation to hide in and surface water for trekking with livestock), and labour surplus means young men are free to raid. Raiding often occurs at wells, but because they are profitable places ot raid, but not due to access.	
Witsenburg & Roba (2002)	International: n>2	State	Global	Even minor skirmishes are found in this century; no war has ever been fought over water. In contrast, 145 water-related treaties were signed in the same period. Cooperation over water, including signing of treaties, outweighed conflict over water and violent conflict in particular.	Low
Wolf (1998)	Intracommunity	Individuals	South America: *Bolivia, squatter settlement in Cochabamba.*	Community operated according to principles of CPR management institutions. Flexibility in rules for water allotment allowed CPR to be managed adaptively during dry seasons but this did not undermine fairness, equity and subsistence ethic. Findings suggest that indicates that well-organized community common pool resource institutions have ability to remain ecologically and socially sustainable	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				during periods of water stress.	
Wutich (2009)	International: n=2 n>2	State	Global	International relations over water are overwhelming cooperative. Where acute conflict is reported, it is related to infrastructure or water quantity, but these instances only involved bilateral interactions. No single indicator - water stress, climate, government type, dependence over water for agricultural or energy needs can explain conflict/cooperation in a basin. Arid regions, not found to be substantially less cooperative than other climatic zones. Most cooperative years were those where rainfall was close to average. Very dry years marginally more cooperative than wet or very wet years. Suggest that may not be overall climate or average precipitation that provides an indicator of conflict, but the occurrence of extremes (physical or institutional changes) or level of uncertainty concerning available water resources in the basin. International relations over freshwater resources were overwhelmingly cooperative and covered a wide range of issues, including water quantity; water quality, joint	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				management, and hydropower. Conflictive relations tended to centre on quantity and infrastructure. No single indicator explained conflict/cooperation over water. Even indicators showing a significant correlation with water conflict, such as high population density, low per capita GDP, and overall unfriendly international relations, explained only a small percentage of data variability. The most promising sets of indicators for water conflict were those associated with rapid or extreme physical or institutional change within a basin and the key role of institutional mechanisms, such as freshwater treaties, in mitigating such conflict.	
Yoffe (2003)	International: n=2 n>2	State	Global	International relations over water are overwhelming cooperative. Where acute conflict is reported, it is related to infrastructure or water quantity, but these instances only involved bilateral interactions. No single indicator - water stress, climate, government type, dependence over water for agricultural or energy needs can explain conflict/cooperation in a basin.	Low

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				Arid regions, not found to be substantially less cooperative than other climatic zones. Most cooperative years were those where rainfall was close to average. Very dry years marginally more cooperative than wet or very wet years. Suggest that may not be overall climate or average precipitation that provides an indicator of conflict, but the occurrence of extremes (physical or institutional changes) or level of uncertainty concerning available water resources in the basin. International relations over freshwater resources were overwhelmingly cooperative and covered a wide range of issues, including water quantity; water quality, joint management, and hydropower. Conflictive relations tended to centre on quantity and infrastructure. No single indicator explained conflict/cooperation over water. Even indicators showing a significant correlation with water conflict, such as high population density, low per capita GDP, and overall unfriendly international relations,	

Study	Spatial Scale	Population focus	Country/ countries studied	Account of result	WoE
				explained only a small percentage of data variability. The most promising sets of indicators for water conflict were those associated with rapid or extreme physical or institutional change within a basin and the key role of institutional mechanisms, such as freshwater treaties, in mitigating such conflict.	

D.4 Study by scale of analysis, region, conceptual framework, outcome and weight of evidence

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
Araral (2009)	Intracommunity	Asia: *Philippines*	Common resource management theory. Collective action outcomes are shaped by the incentive structure faced by the players which is in turn affected by the context they face. The context is defined by the physical characteristic of the resource, the attributes of the players and the internal and external institutional context.	Medium
Bardhan (2000)	Intracommunity	Asia: *6 districts in Tamil Nadu*	Common property management.	Low
Bernauer et al (2010)	Intracommunity: *Intra-group dynamics among agro-pastoralists*	• Global • Africa	Rainfall and temperature indirectly lead to conflict through changes in economic growth. Uses rainfall/ temperature as IV, by first examining relationship between rainfall and economic growth in an econometric model.	Medium
Bogale & Korf (2007)	International: n=2 *Unit of analysis is the dyad-year (year when a*	Africa: *Somali region, Ethiopia*	Agropastoralist households will accommodate pastoralists on their common grazing land only if the private benefits from accommodating the pastoralists exceed the cost they are supposed to incur (the net benefit is positive).	Low

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
	treaty is signed)			
Brochmann & Gleditsch (2006a)	International: n=2	Global	No model, almost absent logical framework. Lack of proper and clearly stated hypothesis.	Medium
Brochmann & Gleditsch (2006b)	International: n=2	Global	Cornucopian framework. Shared rivers are likely to promote cooperation as well as conflict.	Low
Brochmann & Hensel (2008)	Aggregate national level	• Central America • European Union: *Western Europe* • Middle East • North America • South America	Upstream/downstream claims most likely to occur when water is scarce, the river is long (proxy for importance of river e.g. agriculture, energy, navigation), river crosses international boundary rather than acts as a border but likely to experience peaceful settlements. River claims are less likely to begin when river treaties already exist. Using liberal institutionalism theory, argue that dyads with democratic regimes are more likely to cooperate.	Medium

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
Buhaug & Theisen (2010)	International: n=2	Africa	Eco-violence conceptual framework	Medium
Buhaug (2009)	Aggregate national level	Africa: *SSA*	Based on eco-scarcity framework, but no model or hypothesis.	Medium
Burke *et al* (2009)	Aggregate national level	Africa: *SSA*	Variability in temperature and precipitation in highly dependent rain-fed areas leads to conflict due to reductions in agriculture performance.	Medium
Burke *et al* (2010)	Intracommunity	Africa: *SSA*	Eco-security conceptual framework.	Medium
Dayton-Johnson (2000)	International: n=2, n>2	Central America: *Mexico, Guanajuato*	Quality of infrastructure maintenance (cooperation) is related to various 'distributive rules' (water availability) more than structural characteristics (such as group size, inequality).	Medium
De Stefano *et al* (2010)	International: n=2	Global	n/a	Low
Dinar (2009)	International: n=2	Global	Cooperation is most likely to take place when the resource is neither abundant (when there is no real impetus for cooperation) nor highly scarce (when there is little of the resource to divide among the parties or the degradation too costly to manage). Rather, formal coordination in the form of an international water treaty is most likely to ensue at levels of moderate (or relative) scarcity	Low

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
Dinar *et al* (2010)	International: n=2	Global	Predicts a curvilinear relationship between treaties and scarcity. When water is not scarce, riparian states are in less need to cooperate as there is sufficient supply. As scarcity levels increase, the impetus for cooperation increases. But as water becomes extremely scarce, there is little to cooperate over and formalised treaty formation is less likely. Democracy, governance, country relations, trade interdependence, power asymmetries, cross-boundary rivers are also confounding factors.	Medium
Dinar *et al* (2007)	Intracommunity	Global	Resource scarcity, while a source of conflict, is also a driver for cooperation between states - neoliberal theoretical framework. And, specifically predicts an inverted U relationship between cooperation and scarcity.	Medium
Fayankinnu (2005)	Intracommunity	Africa: *Nigeria*	Demand-induced scarcity leads to social conflicts.	Low
Funder *et al* (2010)	International: n=2	Africa: *Namwala district, Zambia*	Water-related conflict and cooperation takes place in response to situations of actual or potential competition (situations in which two or more parties seek access to the same water resources). At times, such conflict or cooperation is latent, while at other times it is expressed as "water events".	Low
Furlong (2006)	Aggregate national level	Global	neo-Malthusian framework.	Medium

Study	**Spatial Scale**	**What country/ countries were studied**	**Conceptual framework/ pathway**	**WoE**
Gizelis & Wooden (2011)	International: n=2	Global	Intrastate water resource conflict is institutionally driven.	Medium
Gleditsch (2006)	International: n=2 n>2	Global	Dyads with rivers running across the boundary would be expected to give rise to resource scarcity-related conflict, while in dyads where the river forms the boundary conflict may arise becaue river boundaries are fluid and fuzzy.	Medium
Raju *et al* (2005)	Aggregate national level	Asia: *India*	Common property management	Medium
Hamner (2009)	Aggregate national level	Global	As a coping strategy with uncertainty and economic disruption (but not conflict) created by droughts, states are more likely to enter into water treaties during times of water stress.	Medium
Hauge (1998)	Aggregate national level	Global	Eco-violence framework (Homer-Dixon)	Medium
Hendrix & Glaser (2007)	International: n=2	Africa: *SSA*	Long-term: Following Collier and Hoeffler (2002, 2004). Land degradation, climatic and freshwater scarcity negatively impact on land productivity associated with lower returns to agriculture , the opportunity cost to violence decreases, leading to the higher likelihood of conflict. However, tropical zones receive high levels of rainfall but are characterise by poor soil quality. Therefore, the relationship between freshwater and conflict may also be positive.	Medium

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
			Short-term (interannual variability): Higher levels of rainfall relative to previous years may be associated with higher returns of agriculture and lower risk of conflict.	
Hendrix (2010)	International: n=2	Africa: Africa-wide. Every country in Africa, including North Africa is coded.	Doesn't provide formal model, but discusses five plausible mechanisms (not mutually exclusive). 1) Intersectoral: Conflict among consumers of water, including those who depend on water as an input for their products; 2) Price disputes between rural producers and urban consumers (e.g. food riots); 3) Internal migration: internal displacement of populations lead to competition over jobs, housing, other resources (inter-communal conflict); 4) Reduced state capacity: negative macroeconomic impacts reduce state capacity and lead to political instability; 5) Long-term macroeconomic impacts: negative development effects of hydro-meteorological disasters can increase risk of conflict.	Medium
Hensel & Brochmann (2007)	Aggregate national level	• European Union: *Western Europe*	Test both neo-Malthusian and neo-liberal theories. Increased water scarcity and water demands makes states more likely to incite river claims and militarised conflict over these claims, but treaties can help prevent emergence and militarization of river claims.	Medium

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
		• Middle East • North America • South America		
Hensel *et al* (2006)	Aggregate national level	Global	High levels of water scarcity increase the frequency of explicit claims over water, increase chances of militarized conflict, and make it more difficult for conflict management institutions to be effectively created.	Low
Kevane & Leslie (2008)	Intracommunity	Africa: *Sudan, Darfur; Sahelian/ West Africa*	None provided	Medium
Levy *et al* (2005)	Intercommunity	• Africa • Asia • Central America • Eastern Europe • Middle East • South America	Variant of neo-Malthusian arguments of scarcity leading to conflict due to weak institutional capacity, deprivation and grievance.	Medium
Makepe (2005)	nternational:	Africa:	Common Property Management. Specifically: water shortages	Medium

Study	Spatial Scale	What country/ countries were studied	Conceptual framework/ pathway	WoE
	n=2	*Botswana*	during the dry season has a positive impact on collective actions (since reliance on borehole during this period raises the stakes for members to act collectively to ensure that water is available on a permanent basis).	
Meier *et al* (2007)		Africa: *Uganda, Ethiopia, Kenya*	Eco-violence theoretical framework (Homer-Dixon; Baechler)	High
Raleigh & Urdal (2007)	International: n=2; n>2	Global	Eco-violence theoretical framework (Homer-Dixon,Baechler)	Medium
Stalley (2003)	Aggregate national level	Global	States experiencing environmental scarcity are more likely to be involved in international conflict.	Medium
Stinnett (2009)	Intercommunit y	Global	Neoliberal theoretical framework. Institutionalisation of river treaties depend on the urgency (degree of scarcity) to cooperate and contextual political factors. High levels of institutionalisation will be difficult to achieve in the absence of factors that make it desirable.	High
Theisen (2008)	Intercommunit y	Global	Environmental scarcity limits capacity to cope with environmental stressors and increases the risk of civil war and armed conflicts.	Medium
Theisen (2010a)	Intercommunit y: *Inter-group*	Africa	Eco-violence theoretical framework. Drought increases the local risk of civil war; and the effect of drought on civil war risk is higher in politically marginalized areas.	Medium

Study	**Spatial Scale**	**What country/ countries were studied**	**Conceptual framework/ pathway**	**WoE**
	conflict			
Theisen (2010b)	International: n=2 *examines treaties between 2 countries*	Africa: *Kenya*	*DES framework (Kahl, 2006). Densely populated areas run a higher risk of inter-ethnic violence. Election years are more prone to conflict than non-election years.*	High
Thiesen & Brandsegg (2007)	International: n=2 *Dyads, boundary-crossing rivers from Correlates of Water contiguity dataset.*	Africa: *SSA*	Neo-Malthusian: Eco-violence theoretical framework (Homer-Dixon/ Baechler)	Medium
Tir & Ackerman (2009)	Intercommunity	Global	Draws on realist, neoliberal neo-Malthusian theories.	Medium
Toset (2000)	International: n>2	Global	Examines a series of hypotheses based on shared river resources and conflict: countries that share a river have more conflict; the more	Low

Study	**Spatial Scale**	**What country/ countries were studied**	**Conceptual framework/ pathway**	**WoE**
			shared rivers, the more conflict; two countries with water scarcity are more likely to have conflict.	
Witsenburg & Roba (2002)	Intracommunity	Africa: *Kenya, Marsabit*	Eco-scarcity conceptual framework (Homer-Dixon, Baechler)	Low
Wolf (1998)	International: n=2 n>2	Global	No model.	Low
Wutich (2009)		South America: *Bolivia, squatter settlement in Cochabama.*	Common property management	Low
Yoffe (2003)		Global	None	

Appendix E – Full references of included documents

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Appendix F – Full references of studies excluded as unable to source at full text

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