WATER

ESTIMATES GLOBAL CLIMATE IMPACT

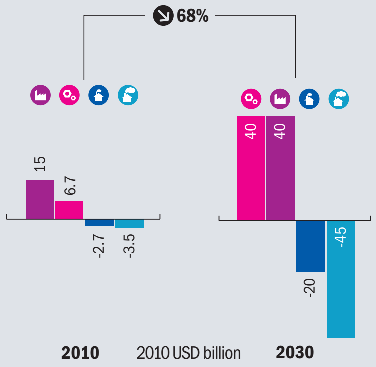
2010 EFFECT TODAY

USD **LOSS** PER YEAR **15 BILLION**

2030 EFFECT TOMORROW

USD **LOSS** PER YEAR **15 BILLION**

ECONOMIC IMPACT



CONFIDENCE
SPECULATIVE

SEVERITY	
AFFECTED	
INJUSTICE	
PRIORITY	
MDG EFFECT	

- Climate change brings extra rain as warmer oceans evaporate more moisture
- Water resources will not increase everywhere: in places more rain may not keep pace with strong heat
- Longer, hotter summers deplete water resources but melting glaciers can cause short-term surges
- Where less or more water is made available to countries already facing chronic water scarcity, losses or gains match heightened marginal water supply costs
- Adapting to impacts of climate change on water is feasible in most cases, but in highly arid regions, solutions may prove too costly

RELATIVE IMPACT

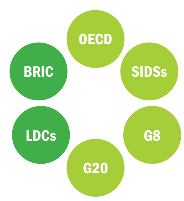
$$$$$$ **2010**
49 | 3

$$$$$$$$$ **2030**
72 | 3

HOTSPOTS

2010		2030
4,000	**MEXICO**	30,000
9,000	**FRANCE**	25,000
5,000	**GERMANY**	15,000
4,750	**SPAIN**	15,000
1,250	**CZECH REPUBLIC**	9,000

GEOPOLITICAL VULNERABILITY



Economic Cost (2010 PPP non-discounted)
Developing Country Low Emitters
Developed
Developing Country High Emitters
Other Industrialized

$ = Losses per 10,000 USD of GDP

Change in relation to overall global population and/or GDP

$ = Millions of USD (2010 PPP non-discounted)

Water is an important input to the full range of economic activities and is therefore a crucial natural resource with market value (Morrison et al., 2009). Rainfall is highly uncertain (Blöschl and Montanari, 2010). Two global climate change projections could show mirror opposites for a region like Brazil: one dry and the other wet (Murray et al., 2012). A full ensemble of IPCC models was used to predict water supply change presented here (Nohara et al., 2006). But selecting only some models as opposed to others would likely have produced a different set of results. For some regions it is more certain whether they will be dry (such as Southern and Eastern Europe and North Africa) or wet (North America, East Asia). Others are completely unsure about what the future holds (Australasia, South America). In this assessment, roughly half of all countries are expected to either gain or have a no impact. The other half will suffer losses. Water is supplied according to specific local conditions at the market price (McKinsey & Company, 2009). However, the price of water varies widely around the world, from more than 8 dollars per m3 in Denmark to less than 8 cents/m3 in parts of India (GWI, 2008). Generally speaking, water costs a larger share of income in most developed than in developing countries. As a result, climate change is contributing to a worsening of water availability in the Mediterranean basin, and generating a large share of estimated global losses.

CLIMATE MECHANISM

Climate change increases rainfall globally, since the planet's water cycle accelerates as it warms (Huntington, 2006). As temperature increases, so does the overall moisture content of the air and rain falls back to ground levels (Allen and Ingram, 2002). More moisture in the air from the world's oceans is the main contributor to the water cycle's acceleration (Syed et al., 2010). However, much of the additional rain falls in the far north or south (Nohara et al., 2006).

Recent evidence shows that rainfall has already declined in the tropics and increased significantly in the far north and south (Helm et al., 2010). Even where more rainfall occurs, if evaporation rates are high due to greatly increased temperature, a loss of water availability can result (Chu et al., 2009). Long-term decline in the world's glaciers and longer drier summers also aggravate water scarcity in certain areas and lead to near-term surges in flows elsewhere before declining again (NSIDC, 2008; Immerzeel et al., 2012; Marengo et al., 2011; Olefs et al., 2009). Economic impacts will cause the greatest challenges where water scarcity and the cost of water are already high (Morrison et al., 2009).

IMPACTS

The effect of climate change on water scarcity is already estimated to cost affected countries 45 million dollars a year. However, 30 billion dollars in yearly gains in water resources in countries experiencing increasing water availability mean a net global loss of 15 billion dollars a year. This net global loss is stable at 15 billion dollars a year to 2030 and declines by three times as a share of global GDP. By 2030, affected countries will incur 200 billion dollars in yearly losses, which are almost entirely offset by similar levels of gains in other countries.

The bulk of losses is estimated to affect wealthy European countries, such as France, Germany, Spain, and Italy. Mexico and Turkey are also expected to experience high losses in absolute terms. Canada, China, Japan, India, and Russia are estimated here to recoup the largest gains.

Southern and Eastern European countries are estimated to be worst affected relative to GDP, along with a number of Central American countries, such as Belize and Panama.

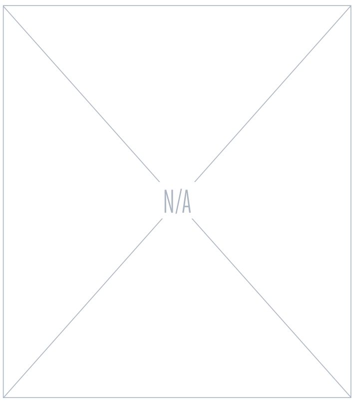
The impacts represent a possible outcome of highly unpredictable rainfall and should be treated with caution, especially for countries in sub-regions with considerable uncertainty about the direction of change (wet or dry).

On a global level, the results could be considered more robust since different hydrological regimes will invariably favour some and disfavour others in terms of water availability.

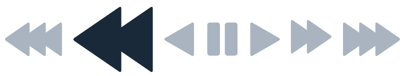
THE BROADER CONTEXT

The world is experiencing a growing water crisis. Between 2010 and 2030, global water demand is expected to increase by around 40%, requiring an additional 3 trillion m3 of water, as compared with a total global demand of only 4.5 trillion m3 today, without accounting for the possible impacts of climate change (McKinsey & Company, 2009). This increase is driven largely by population increases and economic

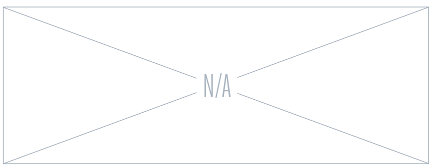
BIGGER PICTURE



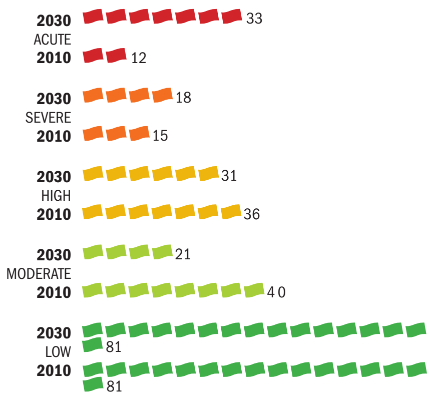
SURGE



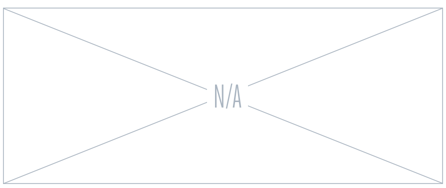
OCCURRENCE



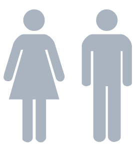
VULNERABILITY SHIFT



PEAK IMPACT



GENDER BIAS



INDICATOR INFORMATION

MODEL: Hoekstra et al., 2010; McKinsey and Company, 2009; Nohara, 2006; Portmann et al., 2010; Rosengrant et al., 2002

EMISSION SCENARIO: SRES A1B (IPCC, 2000)

BASE DATA: Nohara, 2006

= 5 countries (rounded)

Acute Severe High Moderate Low

growth, which brings greater industry demand for water. Over half of the water gap is expected to be met through infrastructure and other changes which deviate from business-as-usual approaches to water. Unless countries develop more sophisticated responses to dealing with the water supply, the expense of closing this gap, while technically possible, will become increasingly cost-prohibitive, because of the steep cost of generating water to compensate for the water scarcity in an economy.

VULNERABILITIES AND WIDER OUTCOMES

Pollution, over-grazing, deforestation, and other environmentally unsustainable practices can all exacerbate water scarcity (Economy, 2010). Farmers who must rely on rainfall alone and who cannot afford or get access to irrigation are highly vulnerable to falling water availability. Water insecurity can lead to food insecurity in marginalized communities and to a lack of water for sanitation and drinking, leading to further negative health consequences, or even violence and conflict (Ludi, 2009; Raleigh, 2010).

Economies heavily reliant on agriculture, responsible for about 70% of global water demand, are also more vulnerable to water stress (FAO AQUASTAT, 2012).

RESPONSES

Managing water often requires large-scale investment that can have an important impact on longer-term development prospects (Aerts and Droogers in Kabat et al. (eds.), 2009). Planning for the wrong outcome is costly. Where uncertainty is high, it is therefore vital that responses are appropriate for a wide range of possible outcomes, i.e., a wet or a dry future (Dessai et al., 2009). However, planning for different outcomes can add significantly to the costs of adaptation. Five broad response areas are central to effective water management: 1) Enhancing catchment capacity or access to supplies, through reservoirs or wells for instance; 2) There is wide scope for improving water efficiency in many contexts (Wallace, 2000), from micro-irrigation, to improved drainage and re-use of water, lining canals and limiting water leakage, as well as the cultivation of more water-efficient crops (Rodríguez Díaz et al., 2007; Wilby and Dessai, 2010; Elliot et al., 2011); 3) Supporting improved institutional environments to enable communities to make and implement effective decisions is critical (Rogers and Hall, 2003); 4) The vulnerability of communities to water stress can also be reduced, whether for socio-economic reasons (e.g., subsistence farmers), pollution, land degradation, or deforestation (Sullivan, 2011; Kiparsky et al., 2012; Epule et al., 2012; Postel and Thompson, 2005); 5) GHG emission reductions do not instantaneously slow or accelerate the hydrological cycle, but will limit the extent of changes in water availability due to climate change in the long term (Wu et al., 2010; Arnell et al., 2011).

THE INDICATOR

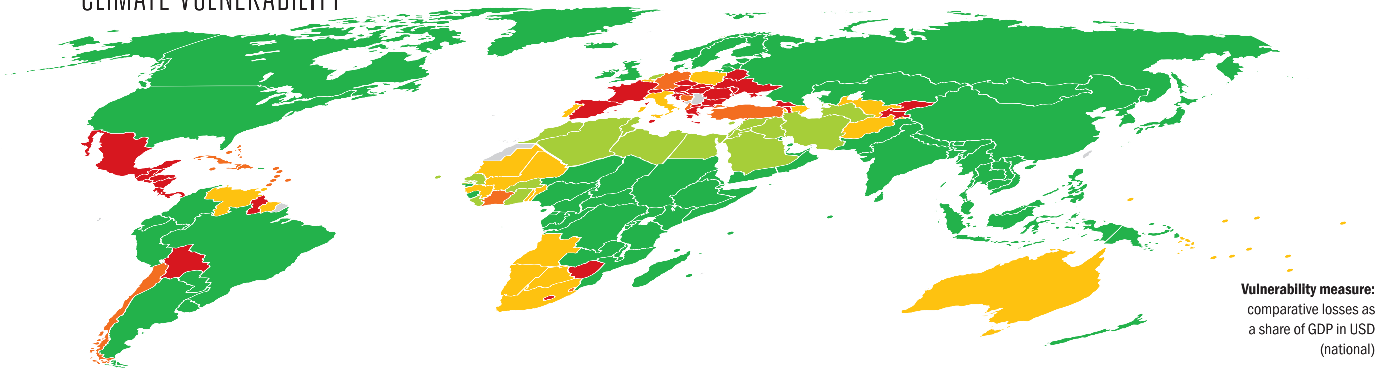
The indicator measures costs of changes in the re-supply of water resources due to temperature and precipitation changes caused by climate change (Nohara et al., 2006). It considers agricultural, domestic/municipal and industrial demand and country or region-specific marginal water costs (Rosengrant at al., 2002; McKinsey & Company, 2009). A key limitation not controlled for is that while climate change may increase water availability over a year, if it does not fall when water demand peaks in the absence of adequate catchment, reservoir and irrigation facilities, water scarcity may still increase. It has been estimated that around 20% of areas experiencing increased water could also experience an increase in water scarcity, including India, Northern China, and Europe (Yamamoto et al., 2012). Since the indicator is aggregating the country-level picture of change, it is possible that increases in water availability for some parts of a country are not compensating fully for decreases in water availability elsewhere.

ESTIMATES COUNTRY-LEVEL IMPACT

	$			
COUNTRY	2010	2030	2010	2030
ACUTE				
Armenia	70	500	0.25	0.50
Austria	2,000	6,000	1	1
Belarus	400	2,500	0.50	1
Belize	35	250		0.25
Bolivia	350	2,500	1	1
Bulgaria	600	4,000	1	1
Costa Rica	150	1,000	0.50	0.75
Croatia	700	4,750	0.50	1
Czech Republic	1,250	9,000	0.75	1
El Salvador	150	1,000	0.00	
France	9,000	25,000	5	10
Georgia	200	1,250	0.75	1
Greece	900	2,750	0.50	1
Guatemala	150	1,250	0.75	1
Guyana	15	100		
Honduras	80	650	0.75	1
Hungary	500	3,500	0.75	1
Kyrgyzstan	40	300	0.75	1
Lesotho	10	65	0.50	0.75
Macedonia	100	850	0.25	0.50
Malta	40	100		
Mexico	4,000	30,000	20	35
Moldova	30	200	0.25	0.50
Nicaragua	75	600	1	1
Panama	200	1,250	0.75	1
Romania	1,000	6,750	1	5
Slovakia	700	5,000	0.50	1
Slovenia	400	2,750	0.25	0.50
Spain	4,750	15,000	5	5
Switzerland	800	2,250	0.50	1
Tajikistan	45	300	0.75	1
Ukraine	1,000	7,000	1	5
Zimbabwe	30	200	1	5
SEVERE				
Albania	35	250	0.25	0.50
Antigua and Barbuda	1	20		
Bahamas	15	100		
Barbados	10	70		
Bosnia and Herzegovina	40	300		0.25
Chile	400	3,250	1	5
Cote d,Ivoire	45	300	1	5
Cuba	150	1,250		
Dominica	1	10		
Dominican Republic	100	950		
Germany	5,000	15,000	1	5
Grenada	1	15		
Haiti	15	100		
Jamaica	35	250		
Saint Lucia	1	20		
Saint Vincent	1	15		
Swaziland	10	70		0.25
Turkey	1,750	5,500	10	20
HIGH				
Afghanistan	35	250	1	5
Angola	70	450	1	1
Australia	750	2,000	0.50	1
Azerbaijan	100	800	0.25	0.50
Belgium	350	1,000	0.25	0.50
Benin	10	75	0.25	0.75
Botswana	20	100		0.25
Fiji	1	20		
Guinea	10	60	0.25	0.75
Italy	2,250	6,750	1	5
Kiribati		1		
Luxembourg	50	150		
Mali	15	95	0.75	1
Marshall Islands		1		
Mauritania	5	40	0.25	0.25
Micronesia		1		
Namibia	10	55		0.25
Palau		1		
Poland	900	6,250	1	1
Portugal	250	700	0.25	0.25
Samoa	1	5		
Solomon Islands	1	5		
South Africa	550	3,500	5	5
Suriname	1	15		
Togo	5	30	0.25	0.50
Tonga	1	5		
Trinidad and Tobago	15	150		0.25
Tuvalu				
Uzbekistan	40	300	0.50	1
Vanuatu	1	5		
Venezuela	350	2,750	1	5
MODERATE				
Algeria	15	95		0.25
Burkina Faso	1	15		0.25
Cape Verde	1	5		
Cyprus	5	15		
Egypt	1	15		
Gambia	1	5		
Ghana	10	55	0.25	0.25
Iran	300	2,250	1	1
Iraq	5	55	0.25	0.25
Israel	10	65		

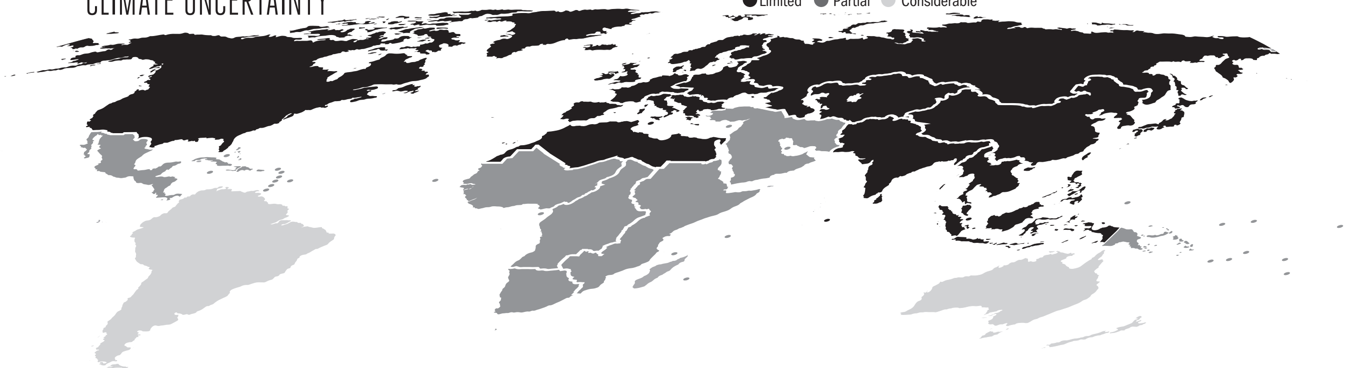
$ Additional economic costs due to climate change (million USD PPP) - yearly average

CLIMATE VULNERABILITY



Vulnerability measure: comparative losses as a share of GDP in USD (national)

CLIMATE UNCERTAINTY



COUNTRY	$ 2010	$ 2030	Water 2010	Water 2030
Jordan	1	10		
Lebanon	1	10		
Liberia	1	1		
Libya	1	5		
Morocco	10	70		0.25
Netherlands	150	500		0.25
Saudi Arabia	20	150		0.25
Senegal	1	5		
Syria	10	65		0.25
Tunisia	1	15		
Turkmenistan	10	75		0.25
LOW				
Argentina	-150	-1,250	-0.25	-0.50
Bahrain	-1	-5		
Bangladesh	-25	-200	-0.50	-1
Bhutan	-85	-700	-0.50	-1
Brazil	-1,250	-10,000	-5	-10
Brunei	-55	-450		-0.25
Burundi	-1	-10	-0.25	-0.25
Cambodia	-15	-150	-0.25	-0.50
Cameroon	-35	-250	-0.75	-1
Canada	-2,500	-7,250	-1	-1
Central African Republic	-5	-25	-0.25	-0.50
Chad	-25	-150	-0.50	-1
China	-5,750	-60,000	-30	-55
Colombia	-250	-2,000	-1	-5
Comoros	-1	-1		
Congo	-5	-50		-0.25
Denmark	-65	-200		
Djibouti	-1	-5		
DR Congo	-20	-100	-1	-5
Ecuador	-750	-5,500	-1	-5

COUNTRY	$ 2010	$ 2030	Water 2010	Water 2030
Equatorial Guinea	-5	-35		
Eritrea				
Estonia	-100	-800	-0.25	-0.50
Ethiopia	-100	-650	-5	-5
Finland	-1,000	-3,000	-0.75	-1
Gabon	-1	-10		
Guinea-Bissau		-1		
Iceland	-25	-70		
India	-2,000	-15,000	-15	-35
Indonesia	-950	-7,500	-10	-20
Ireland	-250	-700	-0.25	-0.25
Japan	-4,250	-10,000	-1	-5
Kazakhstan	-50	-350	-0.25	-0.25
Kenya	-65	-400	-1	-5
Kuwait		-1		
Laos	-70	-750	-1	-1
Latvia	-55	-350		-0.25
Lithuania	-20	-150		
Madagascar	-1	-5		
Malawi	-1	-15		-0.25
Malaysia	-800	-6,000	-1	-5
Maldives	-10	-60		
Mauritius	-10	-65		
Mongolia	-1	-10		
Mozambique	-1	-5		
Myanmar	-75	-600	-1	-5
Nepal	-25	-200	-1	-1
New Zealand	-90	-250		-0.25
Niger	-10	-55	-0.50	-1
Nigeria	-65	-400	-1	-1
North Korea	-20	-200	-0.50	-1
Norway	-1,250	-4,000	-0.75	-1

COUNTRY	$ 2010	$ 2030	Water 2010	Water 2030
Oman	-25	-200		-0.25
Pakistan	-10	-60		-0.25
Papua New Guinea	-100	-850	-5	-5
Paraguay	-25	-200	-0.25	-0.50
Peru	-200	-1,500	-1	-1
Philippines	-45	-350	-0.50	-1
Qatar	-10	-55		
Russia	-2,500	-15,000	-5	-10
Rwanda	-5	-40	-0.25	-0.50
Sao Tome and Principe		-1		
Seychelles	-1	-5		
Sierra Leone		-1		
Singapore	-250	-2,000		
Somalia	-5	-40	-0.50	-1
South Korea	-85	-650	-0.25	-0.50
Sri Lanka	-1	-20		
Sudan/South Sudan	-40	-300	-1	-1
Sweden	-1,500	-4,500	-1	-1
Tanzania	-200	-1,250	-5	-10
Thailand	-300	-2,250	-1	-5
Timor-Leste	-5	-35		
Uganda	-70	-450	-1	-5
United Arab Emirates	-15	-150		
United Kingdom	-1,250	-4,000	-0.75	-1
United States	-1,250	-4,000	-1	-1
Uruguay	-10	-70		
Vietnam	-100	-1,000	-1	-1
Yemen	-10	-60	-0.25	-0.25
Zambia	-1	-5		

Water: Additional water losses/gains due to climate change (km^3) - yearly average